HP ProCurve 6600 Switch Series
Technical Overview
v1.0

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Executive summary

HP ProCurve Networking has an extensive line of networking products built around the concept of the ProCurve Adaptive Network vision that provides the security, mobility, and convergence capabilities businesses demand while giving technology administrators the ability to adapt to the changing needs of their organizations and control their infrastructure centrally.

This guide describes the HP ProCurve 6600 Switch Series and how it builds upon the HP ProCurve Switch 8200zl, 5400zl, 6200yl, and 3500yl Series and the principles of the Adaptive Network by providing a platform for delivering intelligence, performance, and affordability to the edge of the enterprise compute network. Specifically, the HP ProCurve 6600 Switch Series enhances server edge connectivity in the data center by delivering advanced Layer 2/3/4 capabilities that embody the Adaptive Network architecture, where intelligence and decisions are made at the edge of the compute network and effective visibility, provisioning, and automation is provided remotely. With Gigabit and 10-GbE SFP+ options, front-to-back (reversible) airflow, redundant hot-swappable power supplies, and a hot-swappable fan tray, the 6600 switches offer high availability, flexibility, and scalability for a highly virtualized server edge. The HP ProCurve 6600 Switch Series is the industry's first data center edge switch with a lifetime warranty and free software updates.

Introduction

HP ProCurve 6600 Switch Series

The HP ProCurve 6600 Switch Series enhances data center top-of-rack server connectivity and end-of-row aggregation by offering Layer 2/3/4 functionality in 1-GbE copper and 10-GbE SFP+ options.

Audience

This guide is written primarily for technical evaluators and product reviewers of networking equipment and solutions.

Scope

This guide provides detailed information about and specifications for the ProCurve 6600 Switch Series, with the assumption that details about networking protocols can be referenced externally by those familiar with general networking. Technologies that are relatively new will be covered in more detail than more familiar and established technologies.

References to the ProCurve Switch 8200zl, 5400zl, 3500yl, and 6200yl Series are used as they relate to the architecture and positioning of the 6600 switch series.

For more information regarding the complete line of ProCurve products, please visit **www.procurve.com**.

Product positioning

Overview

The intelligence, throughput, scalability, and physical connectivity options of the 6600 series make them suitable for applications at the server edge or aggregation/distribution layer of a compute network. The 6600 switch series leverages the same ProVision ASIC and software found in the widely deployed 8200zl, 5400zl, 6200yl, and 3500zl products. Enhanced for the data center, the 6600 series provides front-to-back (reversible) airflow, redundant hot-swappable power supplies, hot-swappable fan trays, and expanded 10-Gb port buffering for demanding high-availability applications.

The foundation for all of these switches is the purpose-built, programmable ProVision ASIC that allows the most demanding networking features to be implemented in a scalable yet granular fashion. The 6600, 8200zl, 5400zl, 6200yl, and 3500yl series switches have been designed as a continuum of products that utilize a

common code image that enables consistency and scalability throughout the portfolio from data center core to edge. The ProVision ASICs are aimed at achieving several technology and business imperatives.

• Providing superior feature capabilities and performance without sacrificing affordability

• Allowing sophisticated control features in both campus and data center networks

• Enabling programmatic capabilities to safeguard future needs and requirements

Data center use models

The HP ProCurve 6600 Switch Series includes one of the most advanced routing switches in the ProCurve product line. The 6600 switch series is targeted at both top-of-rack server access and end-of-row aggregation/ distribution for enterprise data centers and midmarket compute rooms. The 6600 series products ship standard with the Intelligent Edge feature group, and offer an optional Premium License feature group that includes advanced protocols such as Q-in-Q, PIM-SM, PIM-DM, OSPF-ECMP, and VRRP to support end-of-row use models (RIP and static routing features are included in the standard Intelligent Edge feature group).

The 6600 series was specifically designed to support top-of-rack use models with the intent of supporting highly virtualized server edge deployments for large Layer 2 scale-out systems. The advantages of top-of-rack use models are effectively fourfold:

• **Lower-cost design**: Fixed configuration products offer significant per-port savings over modular-based products. Additionally, top-of-rack products designed to support front-to-back airflow better support hot-aisle and cold-aisle separation to reduce cooling expenses.

• **Enhanced multi-tier network**: Virtualized data centers require expansive Layer 2 footprints to allow for adequate mobility between hypervisors and application scalability. The 6600 series supports 64K MAC addresses for enhanced mobility and scale in the data center.

• **Reduced cabling costs**: With the eventual adoption of 10-Gb at the server edge, direct attach copper cables from the server NIC to the top-of-rack switch significantly reduce the cost per connection versus expensive fiber-optic connections.

• **Easier edge network refresh**: When networking becomes integrated in the rack with servers, technology refreshes become easier to manage as the compute and networking building blocks are effectively deployed in tandem.

Figure 1 provides an example of a three-tiered networking model with top-of-rack networking components.

Data center network

Core

Distribution

Server edge

Standard server edge

Standard servers

ProCurve edge switches deployed as part of a standard solution

Top of rack: enables standard server edge/edge networking racks

Top-of-rack advantages:

• Lower-cost design

• Enhanced multi-tier network designs

• Reduced cabling costs—copper connections from server edge for 10 Gb via direct attach

• Edge network can be refreshed more easily and frequently without disturbing distribution or core layers

→ Network can begin to match server deployment requirements and processes

Server and network "packs"
All applications have standard server deployment

Figure 1: Top-of-rack use model

The 6600 series (specifically the 6600-24XG switch) is also ideal for end-of-row Layer 2 and Layer 3 aggregation, as the 6600-24XG switch provides the highest-density 10-Gb per rack unit in ProCurve's product line. The advanced Layer 3 features provided in the Premium License make the 6600-24XG switch an ideal candidate for aggregation and distribution in the data center. Key features of the ProCurve 6600 series to support both top-of-rack and end-of-row use models include the following:

- **Front-to-back (reversible) airflow**—Enables highly virtualized compute environments where connectivity ports face the hot aisle for use at top of rack. In addition, airflow can be reversed to support end-of-row aggregation and distribution use models where users want data ports facing forward toward the cold aisle.
- **Redundant, hot-swappable power supplies and fans**—Power and fan resiliency as well as in rack-replaceable components to increase availability.
- **64K MAC address scalability**—Supports best-in-class 64K MAC addresses to enable data center scale outs of highly virtualized server environments.
- **Out-of-band management port**—Isolated Ethernet management port provides robust access to the management plane that is truly isolated from in-band data ports (available on 6600-48G, 6600-48G-4XG, and 6600-24XG switches).
- **sFlow for enhanced network visibility**—Supports sFlow packet sampling to provide real-time visibility to monitor traffic across all data ports at up to 10-Gb wire speed.
- **Upgradability**—Premium License option to support advanced Layer 3 functions most commonly needed for end-of-row use models.
- **Performance**—High-capacity switch fabrics (from 48-Gbps to 322-Gbps backplane speed), bandwidth shaping and control, QoS, and Layer 2 and Layer 3 jumbo frames.
- **Security**—ACLs (per-port or identity-driven), virus throttle, out-of-band Ethernet management, switch CPU protection, detection of malicious attacks, DHCP protection, BPDU port protection, dynamic ARP protection, dynamic IP lockdown, IP and MAC lockdown/lockout, IEEE 802.1X, Web, and MAC user authentication, and management access control (SSH, SSL, TACACS+, secure FTP).
- **Resiliency**—Redundant hot-swappable power supply options, hot-swappable fan tray, MSTP, switch meshing, VRRP[1], and OSPF-ECMP[1].
- **IP Routing**—RIPv1/v2, OSPF[1], PIM-SM/DM[1], and static routes.
- **Diagnostic**—Remote intelligent mirroring, loopback interface, UDLD, and sFlow support.

6600 series system overview

The HP ProCurve 6600 Switch Series was designed to be collocated with data center servers for both top-of-rack edge access and end-of-row aggregation and distribution deployment models. To support high availability in a 1U form factor, all 6600 series products allow for redundant hot-swappable power supply options, hot-swappable fan tray, and front-to-back (reversible) airflow, along with out-of-band Ethernet management ports. These are key capabilities that separate the 6600 series from other competitive products as well as other products in the ProCurve portfolio and position it well for data center top-of-rack and end-of-row designs. To allow seamless core-to-edge deployment with ProCurve, the 6600 series shares the same software and hardware building blocks as the 8200zl, 5400zl, 6200yl, and 3500zl products, thus reducing complexity and operating expense.

The base configuration for the 6600 series as shipped from the factory includes the following:

- 1 system fan tray (J9271A)
  - The 6600 ships as a back-to-front direction for ports-reward installation, but the fan tray is mechanically reversible to support front-to-back (ports forward) airflow when positioned as an end-of-row aggregation/distribution switch.

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[1] Requires Premium Software License

- 1 power supply (J9269A)
  - The 6600 series has two power supply bays to support power redundancy.
  - The power supplies are hot-swappable and allow for tool-less serviceability.
  - The 6600 power supplies leverage the 1200 W ProLiant G6 "common-slot" supply to simplify sparing.
- Rack ears for mounting in a two-post telco rack
  - For mounting in a four-post network/server rack, the 6600 rack mount kit (J9469A) that includes telescoping rails is highly recommended.
- AC power cords
  - The system ships with two AC power cords: one is the standard HP line cords using a C13 connector on the power supply side and a country plug on the source end, while the other is a power distribution unit (PDU) jumper cord with a C13 connector on the power supply side and a PDU plug on the source end. With either option, the AC source is: 100 to 120 VAC/200 to 240 VAC; 7.5 A/3.75 A; 50/60 Hz.

Chassis layout

The 6600 switch series are high-density, 1U form factor switches. Figure 2 details the power supply side view of the 6600 series products.

Internal power supply slots
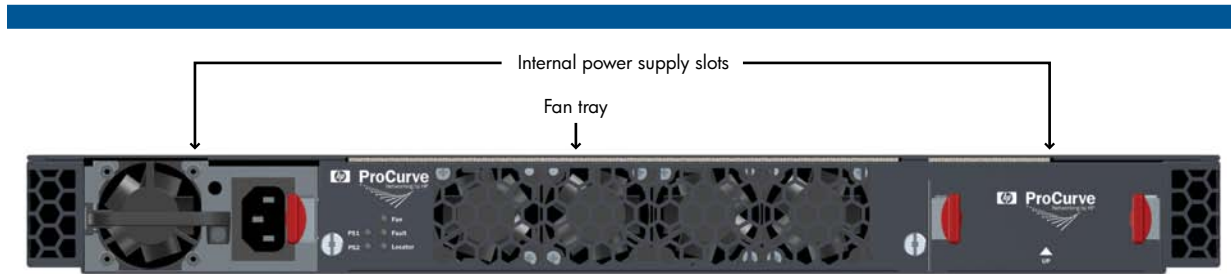
Fan tray

Figure 2: HP ProCurve 6600 Switch Series (power supply side view)

The 6600 fan tray and power supplies are all hot-swappable, so that the switch does not have to be powered off to remove these serviceable components.

System elements

HP ProCurve 6600 Switch Power Supply (J9269A)

Two power supplies need to be installed to take advantage of the power supply hot-swappable capabilities. The power supply slots can accommodate the ProLiant G6 "common-slot" supplies. Currently, the 6600 series only supports the 1200 W AC supply, although the 6600 series is capable of supporting DC and other common-slot supplies.

Two AC-to-12-V DC power supplies can be configured as 1+1 redundant supplies. The system is fully powered with either power supply, and either power supply (but not both) can be removed and replaced while the system is still racked, and the switch will continue to operate. Each power supply input is C14 with proper safety ground.

	110–120 VAC	200–240 VAC
Current	< 7.5 A	< 3.75 A
Output power	> 548 W (> 45.7 A @ 12 VDC)	> 548 W (> 45.7 A @ 12 VDC)
Efficiency (1 supply)	< 677 W @ > 81% efficiency at full load	< 677 W @ > 81% efficiency at full load
Efficiency (2 supplies)	< 677 W @ > 75% efficiency at 50% load	< 677 W @ > 75% efficiency at 50% load

Efficiency calculations include internal fans and line filter. The power supply size is 4.4 inch x 63 inch x 8 inch (57 inch) with an output power density of ~9.6W/inch. The power supply ships with two W40S12BUA5-01 40 mm^2 x 28 mm NIDEC fans or equivalent, producing 36 CFM (18 CFM each) at .5 INWG using 13.2 W (6.6 W each).

In terms of the power supply load-sharing algorithm when two supplies are installed, the power load is shared equally across both supplies to improve longevity. All 6600 series products utilize the same power supply to reduce sparing.
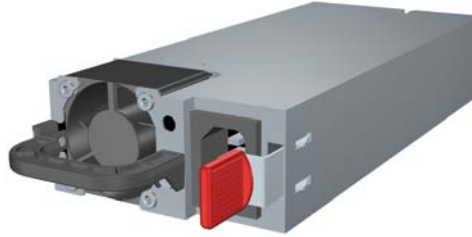
Figure 3: HP ProCurve 6600 Switch Power Supply (J9269A)

HP ProCurve 6600 Switch Fan Tray (J9271A)

The fan tray assembly contains the cooling fans for the interior of the 6600 chassis; the power supplies have their own internal cooling fans. The 6600 fan tray consists of eight variable-speed fans, which offer N+N redundancy. Thus, half of the eight fan rotors can fail and the system will maintain cooling capacity. The fan speed is based on the sensed ambient temperature inside the chassis.

The default airflow configuration for the fan tray is power supply side to port side (front to back, also described as power to port side). Figure 4 shows the default direction for the 6600 series products. The fan tray is mechanically reversible, by first removing the fan tray and then removing the torque screws on sides of the fans assembly. Reversing the fan tray should occur when the system has been powered off to allow adequate time. A position sensor determines the configuration of the fan tray, which is then reported through the CLI as to the direction of the airflow. There is a system configuration option (see section titled "Monitoring airflow direction") to report an error if a replacement fan is installed with the incorrect fan orientation.

To support high-availability data center configurations, the fans tray can be replaced without system shutdown if replacement occurs in under 3 minutes (the 6600 software monitors the time and takes required action to protect the system). Because the fan tray can easily be replaced in less than 30 seconds, the 3-minute service window provides adequate time to make a replacement, but users should replace the fans as quickly as possible. Care must also be taken to install the replacement fan tray to help ensure that the airflow direction is correct for the product's deployment.

To reduce sparing requirements, all 6600 series products utilize the same fan tray.
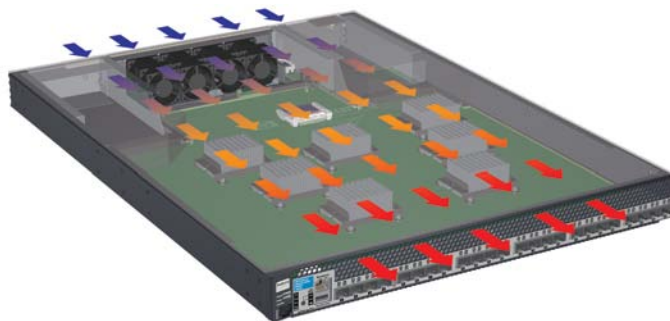
Figure 4: Default airflow direction and connectivity side view of the 6600-24XG switch

In the event of an individual fan failure, an SNMP trap and event log entry is generated. A system can typically operate for quite a long time with a single fan failure (out of the eight), as the remaining fans can increase speed to compensate for the loss of airflow.

The fan tray replicates the Power, Fan, Fault, and Locator LEDs found on the connectivity side of the 6600 switch. This is useful when attempting to locate a 6600 switch while servicing the product from either the hot- or cold-aisle side of the equipment cabinets.
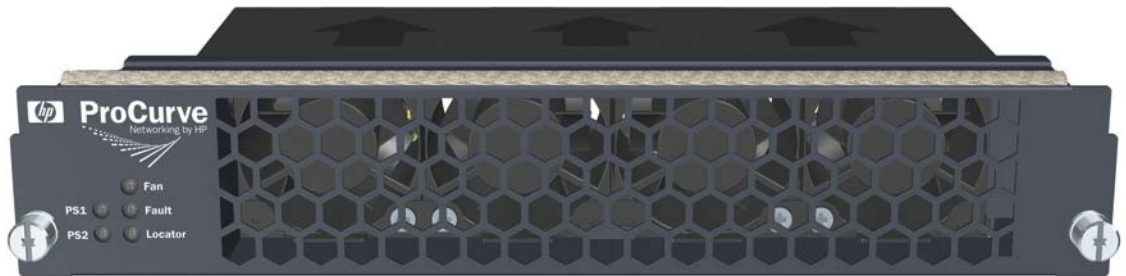
Figure 5: HP ProCurve 6600 Switch Fan Tray (J9271A)

Monitoring airflow direction

The "fan-pref-airflow-dir" CLI command registers the preferred airflow direction (front to back or back to front) in the 6600 switch's configuration file. Because the fan tray is mechanically reversible, it's important for users to monitor when fan hardware configuration does *not* match the desired configuration that is registered in the configuration file. This notification is especially important when replacing a fan tray in a serviceable event. It is important to note that the "fan-pref-airflow-dir" command does *not* change the airflow direction—it must be reversed mechanically. The following sequence details CLI output from a 6600-24G switch where the "fan-pref-airflow-dir" command has been entered:

```
ProCurve Switch 6600ml-24G# sh system fan
   fan-pref-airflow-dir
   fans
ProCurve Switch 6600ml-24G# sh system fans

Fan Information:
```

Num	State	Airflow Direction	Failures
Sys-1	Fan Ok	Power To Port	0

```
* User preferred fan air flow direction is Port to Power

ProCurve Switch 6600ml-24G# sh system fan-pref-airflow-dir
   Preferred fan airflow direction: Port To Power
```

To illustrate the usefulness of the "fan-pref-airflow-dir" command, by default the 6600 switches ship from the factory configured with back-to-front (power side to port side) cooling, with the intention that top-of-rack switches would more likely have their network ports facing toward the back (hot aisle) of the cabinet to facilitate server connectivity. With this intention, the default configuration for the command is, "Power-to-Port", so the "fan-pref-airflow-dir" command will *not* show up in the configuration file—it is the default.

If the user intends to change the airflow so that the preferred direction is Ethernet ports facing the cold aisle, then in the configuration file the use should *change* the preferred direction to be port to power.

Upon change, the user would see:

» Log Entry/Syslog event

» And the "*" and message in the "show system fans" output

If the physical setup of the fans *did not* match this configured parameter—that is, it is there so that if someone forgot to reverse the fans *and* you configured this preference, the user would receive a warning.

If everything matched properly (as they would from the factory), the output of the "show system fans" would simply be as follows, with no warnings or messages:

```
ProCurve Switch 6600ml-24G# sh system fans
Fan Information:
```

Num	State	Airflow Direction	Failures
Sys-1	Fan Ok	Power To Port	0

```
ProCurve Switch 6600ml-24G# sh system fan-pref-airflow-dir
    Preferred fan airflow direction: Power To Port
```

Imagine if someone wanted their ports mounted in the front/cold aisle and they had a warranty replacement of the fan tray—and they forgot to reverse the fans. This event would pop up because the user had configured the 6600 switch with a power-to-port direction (that is, the air is pulled from the back of the unit [the power] and ejected out of the front [the ports]). In this instance, the user would receive a warning.

The SNMP MIB object to manipulate the setting of the "Preferred Fan Direction" is:
hpicfDcFan.mib –> hpicfFanUserPrefAirflowDir

6600 LEDs

The LEDs on the 6600 switch are grouped in two columns.

• One set to indicate the status of system components (power supplies, temperature, fan tray, and so on)

• One set to indicate the switch state (Active, Standby, or Down)

Locator LED

The Locator function is enabled through the following CLI command:

```
ProCurve Switch 6600ml-24G# chassislocate ?
   blink           Blink the chassis locate led (default 30 minutes).
   off             Turn the chassis locate led off.
   on              Turn the chassis locate led on (default 30 minutes).
ProCurve Switch 6600ml-24G# chassislocate blink ?
   <1-1440>        Number of minutes duration (default 30).
   <cr>
```

By indicating a number N after either the "blink" or "on" parameter, the locator LED will extinguish automatically after N minutes. Without specifying a value, the default is 30 minutes.

The LED indicators are covered in more detail in "Appendix G: troubleshooting" later in this document.

Figure 6: Closeup view of the HP ProCurve 6600 Switch Series LEDs

Processor

The CPU processor is a Freescale PowerPC 8540 operating at 667 MHz.

Memory

SDRAM

Synchronous Dynamic RAM (SDRAM) is used for the storage of uncompressed executable code and data structures. The SDRAM consists of a 256 MB DDR-1 DIMM in the base module, expandable up to 1 GB. The DDR-1 interface is 64 bits running at 166-MHz bus speed (333-MHz data rate).

Buffer memory

Table 1 highlights the amount of QDR SRAM allocated for buffer memory for all 1-Gb and all 10-Gb data ports for each of the 6600 series products.

Product	Buffer memory for 1-Gb ports	Buffer memory for 10-Gb ports
6600-24G switch (J9263A)	18 MB	–
6600-24G-4XG switch (J9264A)	18 MB	18 MB
6600-48G switch (J9451A)	36 MB	–
6600-48G-4XG switch (J9452A)	36 MB	36 MB
6600-24XG switch (J9265A)	–	108 MB

Table 1: 6600 series buffer memory configurations

Flash memory

Both 24-port Gigabit products include 256 MB of Compact Flash and 4 MB of mirror-bit flash. All other 6600 series products include 1 GB of Compact Flash memory as well as 4 MB of mirror-bit flash. The mirror-bit flash is used for initial boot code. The Compact Flash is used for nonvolatile configuration storage ("NVRAM"). Compressed image storage and the relatively large storage capacity allow multiple configurations and images to be stored locally to facilitate upgrades and rollbacks during maintenance periods. The Compact Flash card is removable for future upgrade capability if needed.

Because all application code is executed out of SDRAM, the Compact Flash may be programmed while the switch is operational; that is, you can download new code onto the Compact Flash during system operation. The Compact Flash is sized so that a backup copy of an older revision of application code also may be stored.

The system also allows you to hold up to three copies of configuration files, associating them to a particular flash image (primary => Config1, secondary => Config2, Active Running session => Config3).

Console port

The console port allows for RS-232 serial connectivity for local management and configuration. For the 6600-48G, 6600-48G-4XG, and 6600-24XG switches, the console port is an RJ-45 connector. To connect to the console, an RJ45-to-DB9 cable is provided with each switch to connect to the serial port on a laptop. The 6600-24G/6600-24G-4XG products offer a DB-9 serial console port for management access, and a DB-9-to-DB-9 cable is provided. The part numbers for the various console port cables are as follows:

DB9-to-DB9 console cable: 5184-1894 (included with 6600-24G/24G-4XG switch)

RJ45-to-DB9 console adapter: 5189-6795 (included with 6600-48G/48G-4XG/24XG switch)

For a detailed description of the console cable pin-outs, please refer to the "Installation and Getting Started Guide" located at **www.hp.com/rnd/support/manuals/6600dc.htm**

Ethernet out-of-band management (OOBM) port

The 6600-48G, 6600-48G-4XG, and 6600-24XG models offer an RJ-45 10/100 Ethernet management port with isolated CPU and memory resources and a separate TCP/IP stack to provide control of the 6600 switch, even in cases where the in-band network has succumbed to a broadcast storm or has become inaccessible through mis-configuration. The out-of-band management (OOBM) port effectively provides in-band management capabilities in an out-of-band context by enabling key services such as SSH, Telnet, TFTP, HTTP, SNTP, RADIUS, TACACS, DNS, syslog, ping, and traceroute. "Appendix A: out-of-band management port" provides more details about the capabilities of the OOBM port.

Auxiliary (USB) port

The connectivity side of the 6600 series includes a USB auxiliary port that is used to transfer configuration and image files without the need to establish console or network access. The system image and configurations can be copied to a USB memory stick, and the 6600 switch can copy the configuration and image from USB, just as users typically would over the network. The auxiliary port is enabled by default, but can be deactivated as part of the CLI and MIB structure.

The USB port is compatible with the 1.1 USB standard and only supports file storage.

6600 series system architecture

The following section provides an architectural review of each of the HP ProCurve 6600 switches.

HP ProCurve 6600-24G Switch (J9263A)
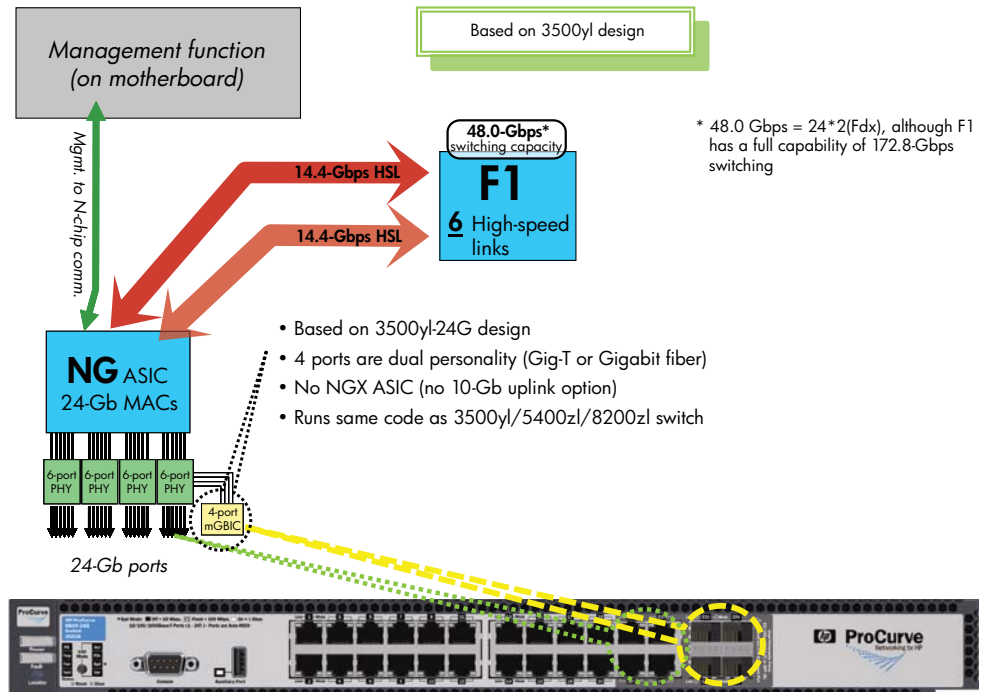
Figure 7: HP ProCurve 6600-24G Switch—ProVision ASIC architecture overview

Description

The HP ProCurve 6600-24G Switch is a data center-optimized, advanced Layer 3 1U stackable switch with 20 10/100/1000Base-T ports and 4 dual-personality ports. The 6600 series 1U form factor switches are enhanced for server edge connectivity with front-to-back cooling, redundant hot-swappable power, and redundant hot-swappable fans. The foundation for all these switches is a purpose-built, programmable ProVision ASIC that allows the most demanding networking features, such as QoS and security, to be implemented in a scalable yet granular fashion. With a variety of connectivity interfaces and expanded buffering, the 6600 switches offer excellent investment protection, flexibility, and scalability, as well as ease of deployment and reduced operational expense.

Ports

- 24 10/100/1000Base-T RJ-45 connectors
- 4 dual-personality 1-GbE SFP (can be used in lieu of last four 10/100/1000Base-T ports)

Management connectivity

- DB-9 serial console port

HP ProCurve 6600-24G-4XG Switch (J9264A)

Based on 3500yl design

Management function
(on motherboard)

Mgmt. to N-chip comm.

105.6-Gbps*
switching capacity

F1

6 High-speed links

14.4-Gbps HSL

14.4-Gbps HSL

14.4-Gbps HSL

14.4-Gbps HSL

* 105.6 Gbps = (24+28.8)*2(Fdx), although F1 has a full capability of 172.8-Gbps switching

NG ASIC
24-Gb MACs

6-port PHY 6-port PHY 6-port PHY 6-port PHY

4-port mGBIC

24-Gb ports

• Based on 3500yl-24G design
• 4 ports are dual personality (Gig-T or Gigabit fiber)
• NGX ASIC with 18-MB packet buffer
  (3500yl series has 4.5 MB and 10-Gb ports)
• Runs same code as 3500yl/5400zl/8200zl switch

NGX ASIC
18-MB pkt buffer
4 10-Gb MACs

Four 10-GbE ports

SFP+ port SFP+ port SFP+ port SFP+ port

Figure 8: HP ProCurve 6600-24G-4XG Switch—ProVision ASIC architecture overview

Description

The HP ProCurve 6600-24G-4XG Switch is a data center-optimized, advanced Layer 3 1U stackable switch with 20 10/100/1000Base-T ports, 4 dual-personality ports, and 4 SFP+ 10-GbE integrated ports. The 6600 series 1U form factor switches are enhanced for server edge connectivity with front-to-back cooling, redundant hot-swappable power, and redundant hot-swappable fans. The foundation for all these switches is a purpose-built, programmable ProVision ASIC that allows the most demanding networking features, such as QoS and security, to be implemented in a scalable yet granular fashion. With a variety of connectivity interfaces and expanded buffering, the 6600 switches offer excellent investment protection, flexibility, and scalability, as well as ease of deployment and reduced operational expense.

The ASIC layout shown in Figure 8 for the data center-focused 6600-24G-4XG switch adds an NGX ASIC to provide a 10-Gb uplink capability to this switch model. Unlike the 3500yl-24G switch, where the yl 10-Gb module is rear mounted, the 6600-24G-4XG switch moves the 10-Gb ports to the front of the switch for simplified cabling.

Examining the Gigabit ports, the last four ports are dual personality, meaning they can be used as RJ-45 copper ports or mGBIC (or SFP) fiber ports. The 6600-24G-4XG switch offers four ports of 10-Gb using SFP+ port slots—instead of X2 slots used on earlier 10-Gb ProCurve products. There is no CX4 option for these SFP+ products, but ProCurve offers a low-cost copper direct attach cable (or DAC) option that is based on the Small Form Factor Committee (SFF-8431) standard. The DACs are essentially a preterminated cable with SFP+ compatible transceivers. DAC products are available in 1-, 3-, and 7-m lengths, primarily for close proximity connections to 10-Gb servers or other SFP+ switches, such as in the same server cabinet. The 6600 accessories portion of this guide provides further details about the direct attach options.

The fabric-switching capacity is listed the same as the 3500yl-24G switch, where we account for the added NGX ASIC and its maximum capacity of 28.8 Gbps of throughput. Table 2 compares the 6600-24G architectures to that of the 3500yl-24G switch.

	2910al-24G	6600-24G	6600-24G-4XG	3500yl-24G
Rack height	1U	1U	1U	1U
1-Gb RJ-45	24	24	24	24
1-Gb SFP	4*	4*	4*	4*
10-Gb SFP+	4 (2 X2/2 CX4)	–	4	4 (2 X2/2 CX4)
Max. 1-Gb wire-speed ports	24	24	24	24
Max. 10-Gb wire-speed ports	4	–	2	2
Management console port	RJ-45	Serial DB-9	Serial DB-9	Serial DB-9
10-Gb port buffering	6 MB**	–	18 MB	4.5 MB
Out-of-band mgmt. port	–	–	–	–
Power save option	–	–	–	–
Power supply	1 internal PS (external PS option)	2 internal PS slots (ships with 1 PS)	2 internal PS slots (ships with 1 PS)	1 internal PS (external PS option)
Routing/Switching capacity	128.0 Gbps	48.0 Gbps	101.8 Gbps	101.8 Gbps
Fabric capacity	128.0 Gbps	48.0 Gbps	105.6 Gbps	105.6 Gbps
Switch throughput	95.2 mpps	35.7 mpps	75.7 mpps	75.7 mpps
MAC address entries	16K	64K	64K	64K
ACL entries	0.5K	3K	3K	3K
Routing table entries	2K	10K	10K	10K

* Dual-personality ports
** 16-MB shared across all 1-Gb and 10-Gb ports

Table 2: 6600-24G/24G-4XG switches vs. 2910-24G and 3500yl-24G switches

Ports

• 24 10/100/1000Base-T RJ-45 connectors

• 4 dual-personality 1-GbE SFP (can be used in lieu of last 4 10/100/1000Base-T ports)

• 4 10-GbE SFP+ ports (10-GbE-only speeds)

• SFP and SFP+ slots are not interchangeable and only support ProCurve-branded optics

Management connectivity

• DB-9 serial console port

HP ProCurve 6600-48G Switch (J9451A)

Management function (on motherboard)

Based on 5400zl design

Mgmt. to N-chip comm.

10/100 Ethernet out-of-band management port

96.0-Gbps* switching capacity

F2

12 High-speed links

14.4-Gbps HSL
14.4-Gbps HSL
14.4-Gbps HSL
14.4-Gbps HSL

* 96.0 Gbps = (24+24)*2(Fdx), although F2 has a full capability of 345.6-Gbps switching

NG ASIC 24-Gb MACs
NG ASIC 24-Gb MACs

• 4-Gb fiber ports (4 dual-personality ports)
• Runs same code as 3500yl/5400zl/8200zl switch
• No NGX ASIC (no 10-Gb uplink option)

6-port PHY 6-port PHY 6-port PHY 6-port PHY

6-port PHY 6-port PHY 6-port PHY 6-port PHY
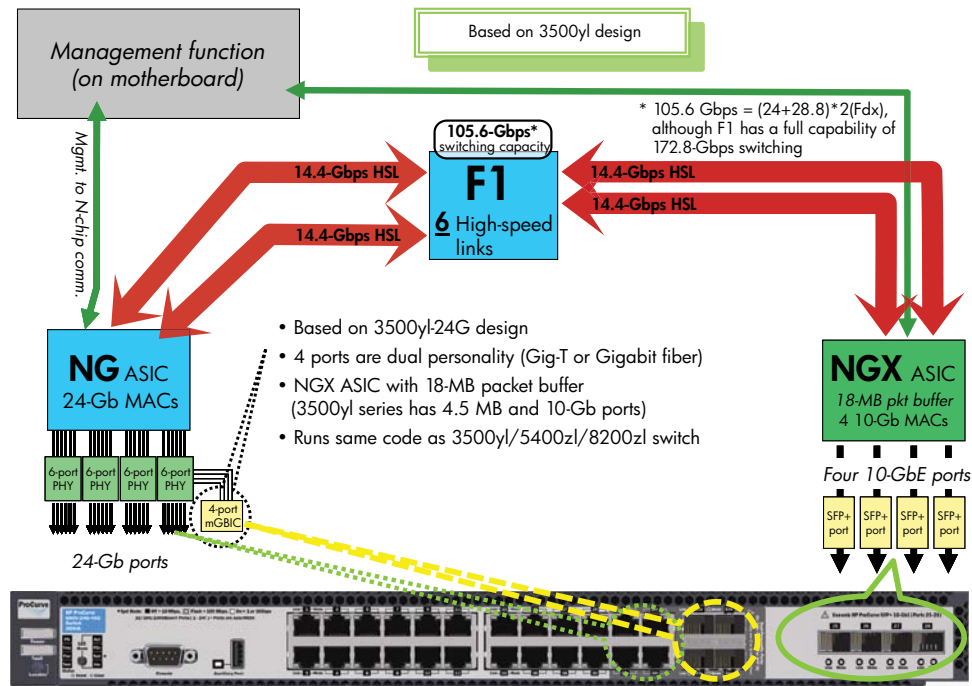
4-port mGBIC

24-Gb ports   24-Gb ports

Figure 9: HP ProCurve 6600-48G Switch—ProVision ASIC architecture overview

Description

The HP ProCurve 6600-48G Switch is a data center-optimized, advanced Layer 3 1U stackable switch with 44 10/100/1000Base-T ports and 4 dual-personality ports. The 6600 series 1U form factor switches are enhanced for server edge connectivity with front-to-back cooling, redundant hot-swappable power, and redundant hot-swappable fans. The foundation for all these switches is a purpose-built, programmable ProVision ASIC that allows the most demanding networking features, such as QoS and security, to be implemented in a scalable yet granular fashion. With a variety of connectivity interfaces and expanded buffering, the 6600 switches offer excellent investment protection, flexibility, and scalability, as well as ease of deployment and reduced operational expense.

The 6600-48G model is configured for 48-Gb copper connections, with the last four ports serving as dual-personality options to accommodate mGBIC (SFP) fiber connections for longer-reach uplinks. Like the 6600-24G switch, the 6600-48G switch does not offer a 10-Gb uplink capability, as the primary use model is for low-cost, top-of-rack aggregation of server iLO ports and other Ethernet-based management ports. Unlike the 6600-24G switch, the 6600-48G switch is based on the 5400zl design, using an F2 fabric ASIC and a newly designed motherboard. Due to this redesign effort, ProCurve offers the 6600-48G/48G-4XG and the 6600-24G/24G-4XG switches with a 10/100BaseT Ethernet out-of-band management (OOBM) port. The OOBM port interfaces directly to the management function on the motherboard to provide an truly separate IP stack that is independent of the Ethernet switch-forwarding plane. The OOBM port is in addition to the RJ-45 serial console port that was first introduced on the HP ProCurve 8212zl chassis. The OOBM port is discussed further in the appendix of the document.

Ports

• 48 10/100/1000Base-T RJ-45 connectors
• 4 dual-personality 1-GbE SFP (can be used in lieu of last four 10/100/1000Base-T ports)

Management connectivity

• RJ-45 serial console port
• RJ-45 Ethernet out-of-band management port

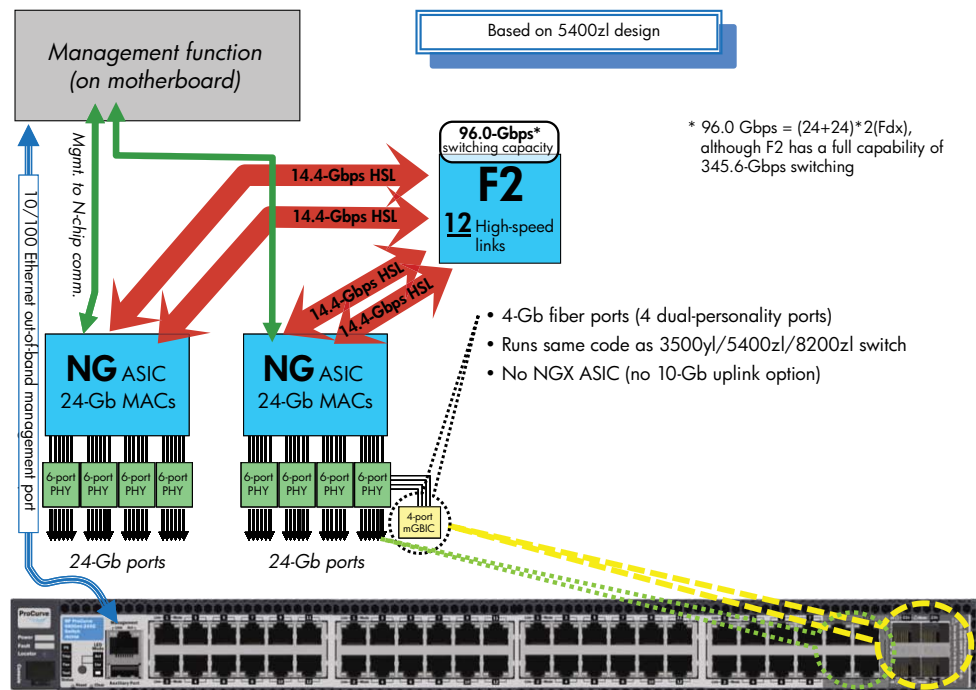# HP ProCurve 6600-48G-4XG Switch (J9452A)

Figure 10: HP ProCurve 6600-48G-4XG Switch—ProVision ASIC architecture overview

Description

The HP ProCurve 6600-48G-4XG Switch is a data center-optimized, advanced Layer 3 1U stackable switch with 48 10/100/1000Base-T ports and 4 SFP+ 10-GbE integrated ports. The 6600 series 1U form factor switches are enhanced for server edge connectivity with front-to-back cooling, redundant hot-swappable power, and redundant hot-swappable fans. The foundation for all these switches is a purpose-built, programmable ProVision ASIC that allows the most demanding networking features, such as QoS and security, to be implemented in a scalable yet granular fashion. With a variety of connectivity interfaces and expanded buffering, the 6600 switches offer excellent investment protection, flexibility, and scalability, as well as ease of deployment and reduced operational expense.

To achieve wire-speed forwarding on all ports, the 6600-48G-4XG model is configured with two NGX 10-Gb ASICs. Each NGX connects to two downstream 10-Gb SFP+ ports, and therefore provides full line-rate capacity across all four 10-Gb ports. Because each NGX is only connected to two 10-Gb ports, the maximum throughput of each NGX ASIC is only counted as 20-Gb full-duplex (or 40-Gb switching). Thus, unlike the 3500yl-48G architecture, where the 4 x 10-Gb module connects to a single NGX ASIC, thereby achieving a maximum throughput of 28.8 Gb across all four 10-Gb ports, the 6600-48G-4XG switch can achieve a 40 Gb of throughput.

Table 3 details the comparison of the 6600-48G/48G-4XG switches, the 2910al--48G, and the 3500yl-48G switches in more detail.

	2910al-48G	6600-48G	6600-48G-4XG	3500yl-48G
Rack height	1U	1U	1U	1U
1-Gb RJ-45	48	48	48	48
1-Gb SFP	4*	4*	–	4*
10-Gb SFP+	4 (2 X2/2 CX4)	–	4	4 (2 X2/2 CX4)
Max. 1-Gb wire-speed ports	48	48	48	48
Max. 10-Gb wire-speed ports	4	–	4	2
10-Gb port buffering	6 MB**	–	36 MB	4.5 MB
Management console port	RJ-45	RJ-45	RJ-45	Serial DB-9
Out-of-band mgmt. port	–	RJ-45 10/100 Ethernet	RJ-45 10/100 Ethernet	–
Power save option	–	Yes	Yes	–
Power supply	1 internal PS (external PS option)	2 internal PS slots (ships with 1 PS)	2 internal PS slots (ships with 1 PS)	1 internal PS (external PS option)
Routing/Switching capacity	176.0 Gbps	96.0 Gbps	176.0 Gbps	149.8 Gbps
Fabric capacity	176.0 Gbps	96.0 Gbps	176.0 Gbps	153.6 Gbps
Switch throughput	130.9 mpps	71.4 mpps	130.9 mpps	111.5 mpps
MAC address entries	16K	64K	64K	64K
ACL entries	0.5K	3K	3K	3K
Routing table entries	2K	10K	10K	10K

* Dual-personality ports
** 6 MB shared across all 1-Gb and 10-Gb ports

Note: The 6600-48G-4XG switch does not support 1-Gb mGBIC/SFP capability. The last four ports are exclusively for 10-Gb SFP+ transceivers; they are not capable of running at Gigabit speeds.

Table 3: 6600-48G/48G-4XG switches vs. 2910al-48G and 3500yl-48G switches

With line-rate processing across all four 10-Gb SFP+ ports, the 6600-48G-4XG switch is an effective solution to provide true non-blocking connectivity to 40-Gb servers with 40-Gb uplink capability (along with the increased packet-buffer capabilities of the 6600 series for its 10-Gb ports—18 MB of packet buffering, in this case, per pair of 10-Gb ports for 36-MB total in available 10-Gb memory). A similarly configured 3500yl-48G switch with its 4 x 10-Gb yl module option would be oversubscribed if connected to 40-Gb servers with only 28.8-Gb maximum throughput. The 3500yl-48G switch is also limited to 4.5 MB of packet buffer memory across all 10-Gb ports.

Ports
• 48 10/100/1000Base-T RJ-45 connectors
• 4 10-GbE SFP+ ports (10-GbE-only speeds)

Management connectivity
• RJ-45 serial console port
• RJ-45 Ethernet out-of-band management port

For high-availability configurations with the 6600-48G-4XG switch, users should considerer trunking the 10-Gb uplinks across odd and even ports to take advantage of the dual paths to separate NGX chips, as show in Figure 11.
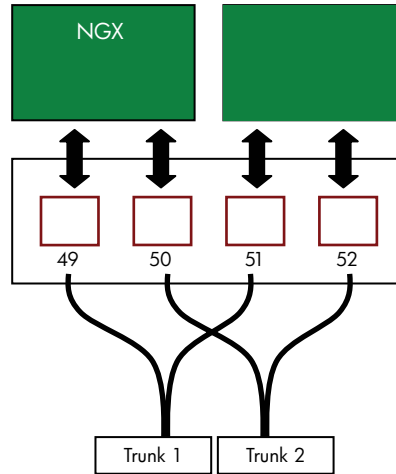
Figure 11: Recommended trunking uplink configuration for the 6600-48G-4XG switch
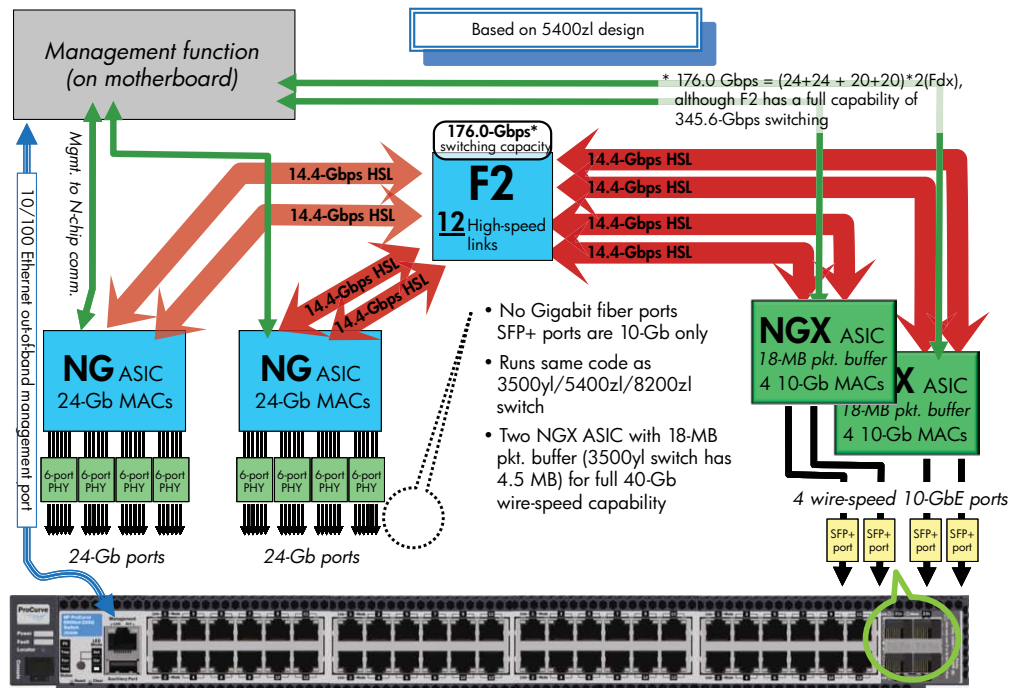
HP ProCurve 6600-24XG Switch (J9265A)
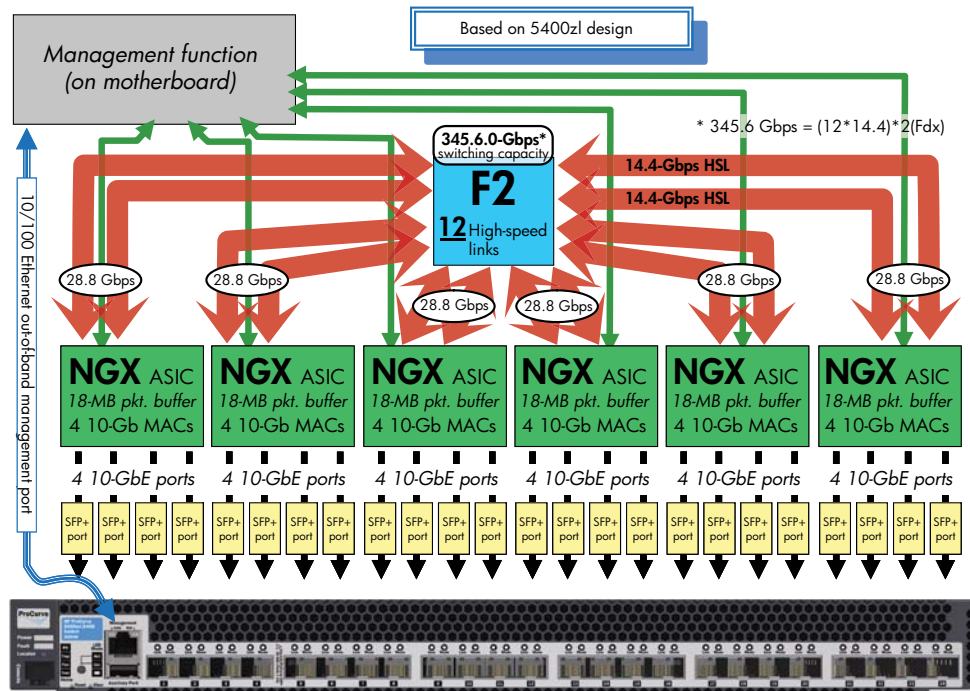
Figure 12: HP ProCurve 6600-24XG Switch—ProVision ASIC architecture overview

Description

The HP ProCurve 6600-24XG Switch is a data center-optimized, advanced Layer 3 1U stackable 24 switch with SFP+ 10-GbE ports. The 6600 series 1U form factor switches are enhanced for server edge connectivity with front-to-back cooling, redundant hot-swappable power, and redundant hot-swappable fans. The foundation for all these switches is a purpose-built, programmable ProVision ASIC that allows the most demanding networking

features, such as QoS and security, to be implemented in a scalable yet granular fashion. With a variety of connectivity interfaces and expanded buffering, the 6600 switches offer excellent investment protection, flexibility, and scalability, as well as ease of deployment and reduced operational expense.

From a design standpoint, the 6600-24XG model is essentially the equivalent of a 5406zl chassis configured with six 4 x 10-Gb modules. Each NGX network chip represents a node in the system with high-speed links (HSLs) connecting to the interconnect fabric—F2 chip. Each HSL provides approximately 14.4 Gbps of data bandwidth and up to 28.8-Gbps total per NGX interface ASIC. In addition, a management plane dedicates a CPU to provide communications control between the NGX and F2 fabric chip. Throughput capacities are the NGX full capacity of 28.8-Gbps full-duplex or 57.6-Gbps switching capacity per NGX ASIC. The datasheet throughput values reflect this full fabric capacity of 345.6 Gbps of switching capacity. The ProVision ASIC architecture section that follows covers a few specifics about the NGX ASIC, specifically port mappings to the HSLs and throughput limitations and caveats.

Enhanced packet buffers

Each 10-Gb set of four ports is sharing an 18-MB packet buffer (compared to the 3500yl and zl modules 4.5 MB of packet buffers).

Ports

• 24 10-GbE SFP+ ports (10-GbE-only speeds)

Management connectivity

• RJ-45 serial console port
• RJ-45 Ethernet out-of-band management port

ProVision ASIC architecture

The ProVision ASIC architecture is the latest-generation ProCurve ASIC technology and is used in the ProCurve 6600 Switch Series, along with the 8200zl, 5400zl, 6200yl, and 3500yl product families. The ProVision ASIC architecture consists of multiple network chips interconnected by an active crossbar fabric chip. Depending on the flavor of the ProVision network chip used, the 6600 series product supports either NG (Gigabit) or NGX (10-Gb) interfaces. Additionally, the 6600-24G/24G-4XG products utilize the F1 fabric ASIC supporting up to high-speed links (HSLs) of 14.4 Gbps each for a maximum theoretical fabric capacity of 172.8 Gbps full duplex, while the 6600-48G/48G-4XG and 6600-24XG switches utilize the F2 fabric ASIC that provides up to 12 HSLs for a maximum theoretical fabric capacity of 345.6 Gbps full duplex.

Inside the ProVision ASIC architecture

Each NG/NGX network chip contains a full, hardware-based Layer 3 routing switch engine as well as Layer 4 filtering and metering capabilities. These latest ProVision ASICs are ProCurve's fourth generation of internally developed switching platforms. The ProVision network switching engines execute all the packet processing, including Layer 2 and Layer 3 lookups, Layer 2/Layer 3/Layer 4 filtering and forwarding decisions, VLAN forwarding and routing, LACP trunking[2], and priority queuing determinations. The ProVision hardware capabilities and software implementation are common across ProCurve 6600, 8200zl, 5400zl, 6200yl, and 3500yl series switching families.

Classification and lookup

When an Ethernet packet first arrives, the classifier section determines the packet characteristics, its source and destination addresses, VLAN affiliation, any priority specification, and so on. The packet is stored in input memory; lookups into the table memory are done to determine routing information; and a ProVision ASIC-specific packet header is created for the packet with this information. This header is then forwarded to the Policy Enforcement Engine.

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[2] ProCurve's term "trunking" is the aggregation of multiple physical links into one logical link. Other vendors may refer to this as Channels or Link Aggregated Groups (LAGs).

Policy Enforcement Engine

The ProVision network ASICs contain the Policy Enforcement Engine. This engine provides fast packet classification to be applied to ACLs, QoS, rate limiting, and some other features through an onboard Ternary Content Addressable Memory (TCAM). Some of the variables that can be used include source and destination IP addresses (which can follow specific users), TCP/UDP port numbers, and ranges (apply ACLs to an application that uses fixed-port numbers or ranges). More than 14 different variables can be used to specify the packets to which ACL and QoS rules, rate-limiting counters, and others are to be applied.

The Policy Enforcement Engine provides a common front end for the user interface to ACLs, QoS, rate limiting, and some other services. In subsequent software releases for the switches, more features can take advantage of the Policy Enforcement Engine to provide a powerful, flexible method for controlling the network environment. For example, traffic from a specific application can be raised in priority for some users, blocked for other users, and limited in bandwidth for still other users. After the Policy Enforcement Engine, the header is then forwarded to the programmable section of the network switch engine.

Network switch engine programmability

Each ProVision ASIC switch engine contains multiple programmable units, making them true network processor units (NPUs). One of the functions of the NPU is to analyze the header of each packet as it comes into the switch. The packet's addresses can be read with the switch, making forwarding decisions based on this analysis. For example, if a packet's IEEE 802.1Q tag needs to be changed to re-map the packet priority, the ProVision ASIC needs to look at each packet to see if any particular one needs to be changed. This packet-by-packet processing has to occur very quickly to maintain overall wire-speed performance—a capability of the ProVision ASICs.

To broaden the flexibility of the ProVision ASICs, a programmable function is included for its packet processing. This NPU function allows the ProCurve designers the opportunity to make future changes or additions in the packet-processing features of the ASIC by downloading new software to it. Thus, new features needing high-performance ASIC processing can be accommodated, extending the useful life of the switch without the need to upgrade or replace the hardware.

ProCurve's first venture into switching ASIC designs began in 1995, with the introduction of the 2000 switch. The concept of adding the programmable functionality of the NPU within a switching ASIC was designed and implemented in the popular ProCurve Switch 4000M product family introduced in 1998. ProCurve's 5300xl programmable capability was a third-generation design based on the original ProCurve Switch 4000M implementation. The programmable capability was used to give both the ProCurve Switch 4000M and Switch 5300xl new ASIC-related features well after initial release of those products. Customers with existing units could benefit from the new features through free software downloads. The customer's investment in the ProCurve Switch 4000M and 5300xl is preserved by providing new functionality not otherwise possible without the ASIC NPU programmability. Being based on the ProCurve Switch 4000M and 5300xl implementations, the NPU capabilities of the ProVision ASICs used in the ProCurve 6600, 8200zl, 5400zl, 6200yl, and 3500yl series are a fourth-generation design, following the designs of the 5300xl and 4000M switch, and the original 2000 switch.

Fabric interfaces

After the packet header leaves the programmable section, the header is forwarded to the fabric interface. The fabric interface makes final adjustments to the header based on priority information, multicast grouping, and other factors, and then uses this header to modify the actual packet header as necessary.

The fabric interface then negotiates with the destination ProVision ASICs for outbound packet buffer space. Finally, the ProVision ASIC's fabric interface forwards the entire packet through the Fabric-ASIC to an awaiting output buffer on the ProVision ASICs that controls the outbound port for the packet. Packet transfer from the ProVision network ASICs to the fabric ASIC is accomplished using the 28.8-Gbps full-duplex connection, which is also managed by the fabric interface.

ProVision ASIC CPU

Each ProVision ASIC contains its own CPU for learning Layer 2 nodes, packet sampling for the XRMON/ sFlow function, handling local MIB counters, and running other module-related operations. Overall, the local CPU offloads the master CPU by providing a distributed approach to general housekeeping tasks associated with every packet. MIB variables, which need to be updated with each packet, can be done locally. The Layer 2 forwarding table is kept fresh through the use of this CPU. Other per-port protocols, such as Spanning Tree Protocol and LACP, also are run on this CPU. The local CPU, being a full-function microprocessor, allows functionality updates through future software releases.

Fabric ASIC

The Fabric ASIC provides the crossbar fabric for interconnecting the modules together. The use of a crossbar allows wire-speed connections simultaneously from any module to any other module. As mentioned in the "ProVision ASIC architecture" section, the connection between the Fabric ASIC and each interface module's ProVision ASIC (either NG or NGX) is through a 28.8-Gbps full-duplex link via two 14.4 Gbps HSLs.

Management subsystem

The management subsystem is responsible for overall switch management and consists of a CPU, flash memory to hold program code, processor memory for code execution, a console interface, and other system support circuitry to interface and control the ProVision ASICs. In the case of the 6600 switch series, the management subsystem is fixed on the motherboard and does not allow for removability or upgradability.

ProVision hardware resiliency

Many functions required in a switch have been implemented in the single ASIC on the module. What takes a number of chips in other vendor products is achieved in a single ProVision ASIC in the 6000 series. This keeps the part count down, raising overall reliability of the module a significant degree.

Another engineering aspect in the ASIC is hardware error detection, with correction in software for the memory used by the switch. This includes the memory used for forwarding the network traffic, such as the routing and forwarding tables, the Policy Enforcement Engine information, multicast tables, and other data structures. Traffic sent across the backplane uses a protocol to check that there is space available at the destination module, so that fabric data is not lost.

6600 series accessories

To facilitate deployment, high-availability configurations, and sparing, the 6600 series offers a variety of accessories to meet a range of needs. Table 4 summaries the various 6600 series accessories that are available.

Product #	Description
J9305A	HP ProCurve 6600 Switch Premium License
J9269A	HP ProCurve 6600 Switch Power Supply
J9271A	HP ProCurve 6600 Switch Fan Tray
J9469A	HP ProCurve 6600 Rack Mount Kit
J9480A	HP ProCurve 6600 Air Plenum
J9481A	HP ProCurve 6600-24G/24G-4XG Plenum

Table 4: 6600 series accessories

HP ProCurve 6600 Switch Premium License (J9305A)

With a flexible approach to upgradability and licensing, the 6600 switches can run the base feature group initially, and then be upgraded later to run the Premium License feature group. The Premium License offers advanced Layer 2 and 3 capabilities, including Q-in-Q, VRRP, PIM-SM, PIM-DM, and OSPF-ECMP. The Premium License can be transferred to another switch, as long as the license remains in the 6600 family.

HP ProCurve 6600 Switch Power Supply (J9269A)

See reference in earlier text to HP ProCurve 6600 Switch Power Supply (J9269A).

HP ProCurve 6600 Switch Fan Tray (J9271A)

See reference in earlier text to HP ProCurve 6600 Switch Fan Tray (J9271A).

Rack mounting options

2-post telco racks

As part of the 6600 series package, each switch ships with rack ears for mounting in 2-post telco racks. Additional rack mount options and accessories are available detailed subsequently below.

4-Post Racks: HP ProCurve 6600 Series Rack Mount Kit (J9469A)

For mounting in 4-post server or networking cabinets, the HP ProCurve 6600 Series Rack Mount Kit is required. The rack kit provides two telescoping rails that span the depth of the cabinet and provide a mounting range that extends from 26 inches to 36 inches. The rail kit supports square-hole caged nut racks utilizing the EIA 310-d hole size of 3/8 inch x 3/8 inch (.0375 in. x .375 in.).

The rail kit also supports round hole racks at 7.2-mm to 7.3-mm diameter. A picture of the 6600 series rail kit is shown in Figure 13, and the mounting instructions can be found at **www.hp.com/rnd/support/manuals/6600dc.htm**.

6600 rail kit contents
Left rail x 1
Right rail x 1
Hardware kit
   Screw x 4
   Stud x 4
   Zip tie x 2
Rack bracket x 2 (5003-1452)

Figure 13: HP ProCurve 6600 Rack Mount Kit (J9469A)

HP 10000 Series Server Racks: 6600 10K Rack Mount Kit (5070-0145)

While the HP ProCurve 6600 Series Rack Mount Kit works with HP 10000 series racks, some customers prefer to order preconfigured server and networking solutions that are rack shipped directly from HP. For these types of orders, the 10K rack mount kit—orderable via the HP part store (**www.partsurfer.hp.com**)—is required. The 10K rack kit provides two fixed rails that span the depth of the cabinet. A picture of the 10K rail kit is shown in Figure 14, and the mounting instructions can be found at **www.hp.com/rnd/support/manuals/6600dc.htm**.
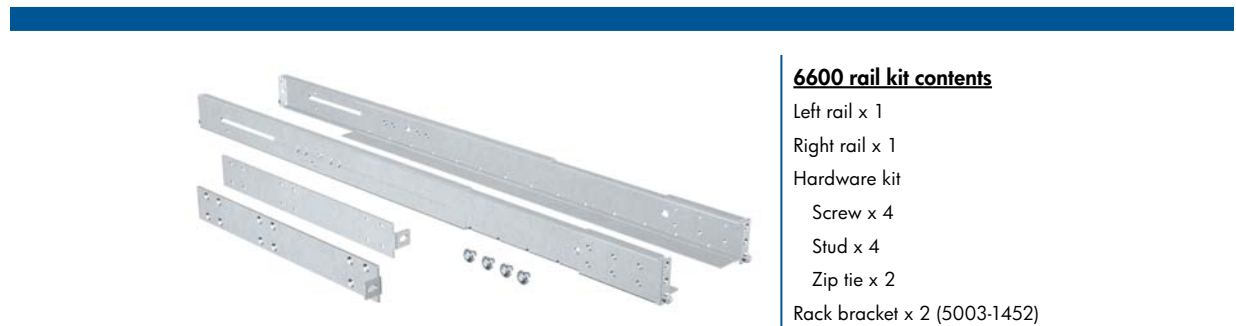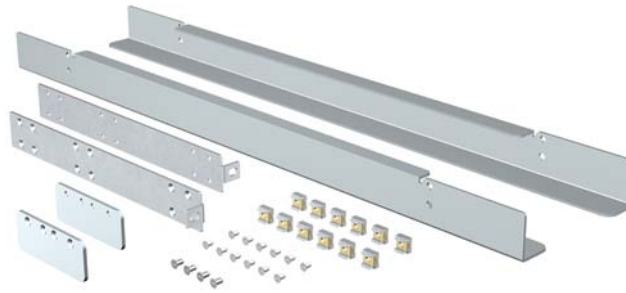
10K rail kit contents

10K rails x 2

M6 screw x 12

M6 cage nut x 12

Captive washer for M6 x 12

    x 4 to attach rail to rack

    x 2 to attach bracket to rack

M4x0.7 8 mm FH screw x 4

Rack bracket x 2 (5003-1452)

Hold-down brackets x 2

Figure 14: HP 10K Rack Kit (5070-0145)

6600 series air plenums

The HP ProCurve 6600 Series Air Plenum is designed to help preserve cold-aisle/hot-aisle separation for improved cooling efficiency when the 6600 switch is collocated with top-of-rack servers. In typical top-of-rack server connectivity environments, the Ethernet ports face the hot aisle to align with server I/O. When a switch is mounted in a server rack, it is typically positioned toward the back of the rack to facilitate cabling, which usually leaves a sizeable air gap in the rack where cold air can flow around the switch. The 6600 series air plenum provides an enclosed pathway where cold air cannot escape around the switch and thus facilitate hot-aisle and cold-aisle separation. This plenum is especially useful in environments where customers are concerned about maintaining temperature and pressure gradients due to limited cooling capacity or to save on cooling costs.

Figure 15 details what the 6600 air plenum would look like mounted with a 6600 switch with the 4-post rail kit.

6600 series air plenum

Hot aisle (40°C) connectivity side

ProCurve 6600 Switch Series

Cold aisle (25°C) power supply side
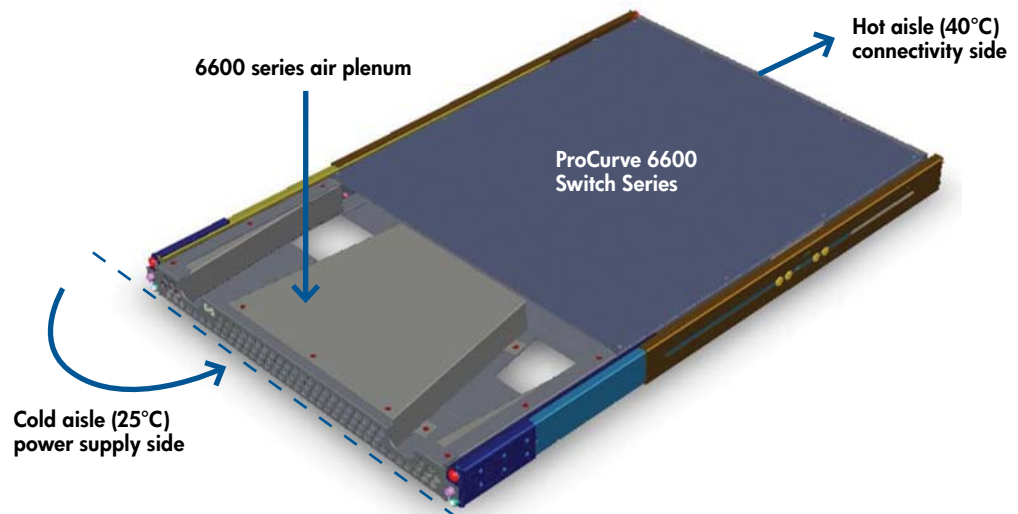
Figure 15: HP ProCurve 6600 Series Air Plenum

HP ProCurve 6600 Series Air Plenum Kit (J9480A)

The 6600 series air plenum helps promote stronger hot-aisle/cold-aisle separation by maintaining temperature and pressure gradients in configurations where the 6600 switch is collocated with servers at the top of rack. The air plenum prevents cold air from leaking around sides of the 6600 switch to promote more efficient cooling and is recommended with installations where the where 6600 switch is mounted with Ethernet ports facing the hot aisle. The 6600 series air plenum (J9480A) is designed for use with the 6600-48G, 6600-48G-4XG, and 6600-24XG switches. Figure 16 details the air plenum kit.

Note: For use with the 6600-48G, 6600-48G-4XG, and 6600-24XG switches

Figure 16: HP ProCurve 6600 Series Air Plenum Kit (J9480A)

HP ProCurve 6600-24G/24G-4XG Air Plenum (J9481A)

The 6600-24G/24G-4XG air plenum is used with 6600-24G and 6600-24G-4XG switches that require a longer plenum due to shorter product depth. The plenum helps promote stronger hot-aisle/cold-isle separation by maintaining temperature and pressure gradients in configurations where the 6600 switch is collocated with servers at the top of rack. The air plenum prevents cold air from leaking around sides of the 6600 switch to promote more efficient cooling and is recommended with installations where the 6600 switch is mounted with Ethernet ports facing the hot aisle. Figure 17 details this particular air plenum.

Note: For use with the 6600-24G and 6600-24G-4XG switches

Figure 17: HP ProCurve 6600-24G/24G-4XG Air Plenum (J9481A)

Transceivers and direct attach cables

Depending on the needs of the environment, the 6600 series provides a range of optics choices to best match the desired configuration. Many of the 6600 series switch models provide dual-personality ports to allow for SFP 1-Gb connectivity over longer distances that exceed copper ranges. Additionally, most of the 6600 series switches also support SFP+ for 10-Gb connectivity with both fiber-optic transceiver as well as low-cost options over shorter runs using direct attach cables (DACs). As detailed below, the DACs come in 1-m, 3-m, and 7-m lengths to facilitate uplinks from to aggregation switches at the end or row or to also allow for server connectivity for those devices that support 10-Gb NICs.

1-Gb SFP (mini-GBIC) transceivers

• J8177B—HP ProCurve Gigabit 1000Base-T Mini-GBIC

• J4858B—HP ProCurve Gigabit-SX-LC Mini-GBIC

• J4859B—HP ProCurve Gigabit-LX-LC Mini-GBIC

• J4860B—HP ProCurve Gigabit-LH-LC Mini-GBIC

10-Gb SFP+ transceivers

- J9150A—HP ProCurve 10-GbE SFP+ SR Transceiver
- J9151A—HP ProCurve 10-GbE SFP+ LR Transceiver
- J9152A—HP ProCurve 10-GbE SFP+ LRM Transceiver

10-Gb SFP+ direct attach cables

- J9281B—HP ProCurve 10-GbE SFP+ 1m Direct Attach Cable
- J9283B—HP ProCurve 10-GbE SFP+ 3m Direct Attach Cable
- J9285B—HP ProCurve 10-GbE SFP+ 7m Direct Attach Cable

Because SFP+ is a relatively new optical form factor for ProCurve, Table 5 provides a comparison between SFP and X2 for those more familiar with X2 transceiver options.

Feature	SFP+	X2
Power consumption		
SR	1 W/port	4 W/port
LRM	1.5 W/port	4 W/port
LR	1 W/port	4 W/port
Twinax direct attach cable	0.1 W/port (estimated)	–
Connector type	LC	SC

Table 5: SFP+ vs. X2 optics

Overview of features and benefits

The ProCurve 6600 Switch Series, like the 8200zl, 5400zl, 6200yl, and 3500yl series switches, uses the same software image base (letter designated K-code, for example, K.14.xx). The 6600 switch series offers a premium software license for advanced Layer 2 and Layer 3 services: Q-in-Q, PIM-SM, PIM-DM, OSPF-ECMP, and VRRP. The primary differences among the ProVision switch families are hardware-related and include such aspects as port density and PoE support, as well as support for redundant power supplies and fans.

The following summary of features and benefits applies to the ProCurve 6600 Switch Series.

Feature	Benefits
Data center optimized	
Seamless core-to-edge capabilities	Reduces complexity and provides choice and flexibility for top-of-rack and end-of-row server connectivity.
Front-to-back, reversible airflow	Enhances airflow to align with servers and storage to promote lower-cost top-of-rack networking architectures, reduces cooling needs.
Redundant, hot-swappable fan tray	N+N fans improve availability and serviceability that increase uptime.
Redundant, hot-swappable power supplies	N+1 power supply configuration improves uptime.
64K MAC address scalability	Industry-leading MAC address table size facilitates data center.
sFlow for enhanced network visibility	Supports sFlow packet sampling to provide real-time visibility to monitor traffic across all data ports at up to 10-Gb wire speed.
Enhanced buffering	Improves network utilization for "bursty" client/server transactions, such as iSCSI and Web 2.0 applications.
Jumbo frames	Provide scalability in throughput up to frame sizes of 9216 bytes for iSCSI attachment.
Automated server provisioning	Integrates seamlessly with ProCurve Data Center Connection Manager and HP Network Automation management tool suite to simplify provisioning and reduce operating expense.

Feature	Benefits
Performance	
ProVision ASIC technology	Powered by the ProVision ASICs, the switch families offer state-of-the-art, high capacity, switch fabric performance.
Selectable queue configurations	Increase performance by selecting the number of hardware-forwarding queues and associated memory buffer that best meet the requirements of network applications.
Security enabled	
Source port filtering	Allows customers to control port access at the physical level—increasing security in a Layer 2 environment.
IP and MAC lockdown/ lockout	Provides protection against known unauthorized hosts accessing the network.
Virus throttle	Connection rate-filtering thwarts viruses from spreading by blocking routing from certain hosts exhibiting abnormal traffic behavior.
ICMP rate limiting	Throttles denial-of-service (DoS) attacks or other malicious behavior that uses high-volume ICMP traffic.
Switch CPU protection	Provides automatic protection against malicious network traffic trying to shut down the switch.
Detection of malicious attacks	Monitors 10 types of network traffic and sends warnings when anomalies potentially caused by malicious attacks are detected.
DHCP protection	Blocks DHCP response packets from being forwarded if received from an unauthorized port.
BPDU port protection	Blocks Bridge Protocol Data Unit (BPDU) on ports that should not be receiving BPDUs, preventing forged BPDU attack.
Dynamic ARP protection	Blocks ARP broadcast from unauthorized hosts, preventing eavesdropping or data theft of network data.
Dynamic IP lockdown	Works with DHCP protection to block traffic from unauthorized host, preventing IP source address spoofing.
Filtering capabilities	Include fast, flexible access control lists (up to 3,000) filtering on such parameters as source port, multicast MAC address, and other protocols.
ProCurve Identity Driven Manager (IDM)	ProCurve IDM to dynamically apply security, access, and performance settings to infrastructure devices based on approved user, location, and time.
Port security	Port security, MAC lockdown, and MAC lockout protection for restricting access to the network through a switch port.
Multiple user authentication methods	Client-based access control using IEEE 802.1X, Web-based, MAC-based authentication, RADIUS, and TACACS+. At initial release, the combinations of authentication methods allowed simultaneously on a port are IEEE 802.1X/ Web and 802.1X/MAC.
Secure management access	SSH, SSL, TACACS+, and Secure FTP encryption of switch management and configuration traffic—secures the network infrastructure from unauthorized access.
Redundancy and high availability	
Redundancy protocols	Protocols providing high availability include IEEE 802.1Q Multiple Spanning Tree Protocol, Switch Meshing, and Virtual Router Redundancy Protocol (Premium License).
Operational Intelligence	
Policy Enforcement Engine	Policy Enforcement Engine is user-configured to select packets that are then forwarded or dropped (based on ACLs, QoS, and rate limiting). The engine is fast and can look for multiple variables, such as an IP address and port number, in a single pass through a packet. Provides a common user experience regardless of which switch the user is connected.
Operational flexibility	
L3 services at L2	Enforce ACLs, QoS, and other features using Layer 2/3/4 source, destination, and port addresses without needing an expensive software license.
Premium License	Flexible approach to licensing. The 6600 switches can run the base feature group initially and then be upgraded later to run the Premium License feature group, if advanced Layer 3 features are needed. The Layer 3 features include VRRP, PIM-SM, PIM-DM, and OSPF-ECMP. A Premium License can be transferred to another switch, as long as the license remains in the same hardware family.
QoS enforcement	
Bandwidth shaping/control	Guaranteed minimums can be applied to traffic that must always get through the switch. Enforced maximums can be used to limit problem clients' bandwidth to no more than a set amount.
Multiple QoS parameters	QoS based on TCP/UDP ports and other variables allows precise control of packet priority—providing timely delivery of mission-critical data. Eight priority levels mapped to eight hardware queues can be used to set outgoing IP priority.

Feature	Benefits
Supports standard protocols	
IP Routing	Supports RIPv1, RIPv2, OSPF, OSPF-ECMP, and static routes.
	OSPF requires the Premium License for the 6600, 5400zl, and 3500yl switches.
	Is standard on the 8200zl and 6200yl series switches.
VLANs	Supports IEEE 802.1Q with 2,048 concurrent VLANs, Group VLAN Registration Protocol (GVRP).
IP Multicast	Supports PIM-SM, PIM-DM, and IGMP data-driven snooping.
Low cost of ownership	
Future-proofing	Programmable ASICs allow some future requirements to be implemented without replacing the switch.
	Intelligent Edge features can be upgraded to Premium License features on the 6600, 5400zl, and 3500yl switches, allowing an edge switch to be redeployed as a distribution switch.
ProCurve Lifetime Warranty*	Next-business-day advance replacement for as long as you own the product (available in most countries).
	Applies to all components and accessories of the 6600 series.

Feature set summary

Additional details about the ProCurve 6600 Switch Series and 8200zl, 5400zl, 6200yl, and 3500yl series features include the following:

Data center optimized

- **Front-to-back airflow**: designed to be collocated at the top of a server rack, the 6600 series supports front-to-back airflow (mechanically reversible) to support hot-aisle/cold-isle configurations; the N+N fan tray is also hot-swappable, allowing easy replacement in the rack
- **Modular internal power supplies**: supports redundant, hot-swappable power supply configurations (units ship with one supply); power load is shared across dual supplies
- **Server-to-switch distributed trunking**: supports Layer 2 LACP groups from a single server across two different switches for active-active server NIC teaming configurations
- **Power-down idle ports**: power down blocks of idle Gigabit and 10-GbE ports to save power; idle ports can be reinitialized without rebooting; available on 6600-24XG, 6600-48G, and 6600-48G-4XG models
- **Out-of-band management**: remotely monitor and manage switch via Ethernet out-of-band management port; eliminate need for terminal server network; available on 6600-24XG, 6600-48G, and 6600-48G-4XG models
- **Deployment/serviceability**: data connectivity and management ports are all front-side accessible, and power supplies and fan trays are rear-side accessible to allow for easy maintenance and in-rack serviceability

Management

- **Remote Intelligent Mirroring**: mirrors ingress/egress ACL-selected traffic from a switch port or VLAN to a local or remote 8200zl, 6600, 6200yl, 5400zl, and 3500yl switch port anywhere on the network
- **RMON, XRMON, and sFlow v5**: provide advanced monitoring and reporting capabilities for statistics, history, alarms, and events
- **Uni-Directional Link Detection (UDLD)**: monitors cable between two switches and shuts down the ports on both ends if the cable is broken turning the bi-directional link into uni-directional; this prevents network problems such as loops

* For as long as you own the product, with next-business-day advance replacement (available in most countries). The following hardware products have a five-year hardware warranty for the disk drive and lifetime hardware warranty (for as long as you own the product) for the rest of the module: HP ProCurve ONE Services zl Module, HP ProCurve Threat Management Services zl Module, and HP ProCurve MSM765zl Mobility Controller. The following hardware products and their related series modules have a one-year hardware warranty with extensions available: HP ProCurve Routing Switch 9300m series, HP ProCurve Switch 8100fl series, HP ProCurve Network Access Controller 800, and HP ProCurve DCM Controller. The following hardware products have a one-year hardware warranty with extensions available: HP ProCurve M111 Client Bridge, HP ProCurve MSM3xx-R Access Points, HP ProCurve MSM7xx Mobility and Access Controllers, HP ProCurve RF Manager IDS/IPS Systems, HP ProCurve MSM Power Supplies, HP ProCurve 1-Port Power Injector, HP ProCurve CNMS Appliances, and HP ProCurve MSM317 Access Device. Standalone software, upgrades, or licenses may have a different warranty duration. For details, refer to the ProCurve Software License, Warranty, and Support booklet at **www.hp.com/go/procurve/warranty**

- **IEEE 802.1AB Link Layer Discovery Protocol (LLDP)**: automated device discovery protocol for easy mapping by network management applications
- **Management simplicity**: common networking features and CLI implementation (common throughout HP ProCurve 8200zl, 6600, 6200yl, 5400zl, and 3500yl switches)
- **Command authorization**: leverages RADIUS to link a custom list of CLI commands to individual network administrator's login; also provides an audit trail
- **Friendly port names**: allow assignment of descriptive names to ports
- **Multiple configuration files**: can be stored to the flash image
- **Dual flash images**: provide independent primary and secondary operating system files for backup while upgrading

Connectivity

- **IPv6**:
  - **IPv6 Host**: switches are managed and deployed at the IPv6 network's edge
  - **Dual stack (IPv4/IPv6)**: transitions from IPv4 to IPv6, supporting connectivity for both protocols
  - **MLD snooping**: forwards IPv6 multicast traffic to the appropriate interface, preventing traffic flooding
  - **IPv6 ACL/QoS**: supports ACL and QoS for IPv6 network traffic
  - **IPv6 ready**: switch hardware can support IPv6 routing, tunneling, and security—available when enabled via software updates in follow-on releases
- **Auto-MDIX**: automatically adjusts for straight-through or crossover cables on all 10/100 and 10/100/1000 ports
- **Jumbo frames**: on Gigabit and 10-Gb ports, allow high-performance remote backup and disaster-recovery services with frame size of 9,216 bytes

Performance

- **High-speed/capacity architecture**: based on the purpose-built ProVision ASICs to provide superior system performance and scalability
- **Selectable queue configurations**: increase performance by selecting the number of queues and associated memory buffering that best meet the requirements of network applications

Resiliency and high availability

- **IEEE 802.3ad Link Aggregation Control Protocol (LACP) and ProCurve trunking**: support up to 60 trunks, each with up to 8 links (ports) per trunk
- **IEEE 802.1s Multiple Spanning Tree**: provides high link availability in multiple VLAN environments by allowing multiple spanning trees; provides legacy support for IEEE 802.1d and IEEE 802.1w
- **Virtual Router Redundancy Protocol (requires Premium License)**: VRRP allows groups of two routers to dynamically back each other up to create highly available routed environments
- **Server-to-switch distributed trunking**: allows a server to connect to two switches with one logical trunk that consists of multiple physical connections; enables load-balancing and increases resiliency
- **Sparing simplicity**: common power supplies, fan trays, and transceivers are used among the 6600 series products

Layer 2 switching

- **ProCurve switch meshing**: dynamically load-balances across multiple active redundant links to increase available aggregate bandwidth
- **GARP VLAN Registration Protocol**: allows automatic learning and dynamic assignment of VLANs
- **IEEE 802.1ad Q-in-Q (requires Premium License)**: increases the scalability of Ethernet network by providing a hierarchical structure; connects multiple LANs on high-speed campus or metro network
- **IEEE 802.1v protocol VLANs**: isolate select non-IPv4 protocols automatically into their own VLANs

Layer 3 services

- **Loopback interface address**: defines an address in RIP and OSPF that can always be reachable, improving diagnostic capability
- **UDP helper function**: UDP broadcasts can be directed across router interfaces to specific IP unicast or subnet broadcast addresses and prevent server spoofing for UDP services such as DHCP

Layer 3 routing

- **RIP**: provides RIPv1 and RIPv2 routing
- **Static IP routing**: provides manually configured routing; includes ECMP capability
- **OSPF (requires Premium License)**: includes host-based ECMP to provide link redundancy/scalable bandwidth and NSSA

Security

- **Source-port filtering**: allows only specified ports to communicate with each other
- **RADIUS/TACACS+**: eases switch management security administration by using a password authentication server
- **Secure Shell (SSHv2)**: encrypts all transmitted data for secure, remote command-line interface (CLI) access over IP networks
- **Port security**: allows access only to specified MAC addresses, which can be learned or specified by the administrator
- **MAC address lockout**: prevents particular configured MAC addresses from connecting to the network
- **Detection of malicious attacks**: monitors 10 types of network traffic and sends a warning when an anomaly that potentially can be caused by malicious attacks is detected
- **Secure FTP**: allows secure file transfer to/from the switch; protects against unwanted file downloads or unauthorized copying of switch configuration file
- **Switch management logon security**: can require either RADIUS or TACACS+ authentication for secure switch CLI logon
- **Secure management access**: all access methods—CLI, GUI, or MIB—are securely encrypted through SSHv2, SSL, and/or SNMPv3
- **ICMP throttling**: defeats ICMP denial-of-service attacks by enabling any switch port to automatically throttle ICMP traffic
- **Virus throttling**: detects traffic patterns typical of WORM-type viruses and either throttles or entirely prevents the ability of the virus to spread across the routed VLANs or bridged interfaces, without requiring external appliances
- **STP BPDU port protection**: blocks Bridge Protocol Data Units (BPDUs) on ports that do not require BPDUs, preventing forged BPDU attacks
- **Dynamic IP lockdown**: works with DHCP protection to block traffic from unauthorized hosts, preventing IP source address spoofing
- **DHCP protection**: blocks DHCP packets from unauthorized DHCP servers, preventing denial-of-service attacks
- **Dynamic ARP protection**: blocks ARP broadcasts from unauthorized hosts, preventing eavesdropping or theft of network data
- **USB Secure Autorun**: deploys, diagnoses, and updates switch using USB flash drive; works with secure credential to prevent tampering
- **STP Root Guard**: protects root bridge from malicious attack or configuration mistakes
- **Management Interface Wizard**: CLI-based step-by-step configuration tool helps ensure that management interfaces such as SNMP, telnet, SSH, SSL, Web, and USB are secured to desired level
- **Access control lists (ACLs)**: provide filtering based on the IP field, source/destination IP address/subnet, and source/destination TCP/UDP port number on a per-VLAN or per-port basis

- **Multiple user authentication methods**:
  - **Multiple IEEE 802.1X users per port**: provides authentication of multiple IEEE 802.1X users per port; prevents user "piggybacking" on another user's IEEE 802.1X authentication
  - **Web-based authentication**: authenticates from Web browser for clients that do not support IEEE 802.1X supplicant; customized remediation can be processed on an external Web server
  - **MAC-based authentication**: client is authenticated with the RADIUS server based on client's MAC address
  - **Concurrent IEEE 802.1X, Web, and MAC authentication schemes per port**: switch port will accept up to 32 sessions of IEEE 802.1X, Web, and MAC authentications
- **Switch CPU protection**: provides automatic protection against malicious network traffic trying to shut down the switch
- **Identity-driven ACL**: enables implementation of a highly granular and flexible access security policy specific to each authenticated network user
- **Secure Sockets Layer (SSL)**: encrypts all HTTP traffic, allowing secure access to the browser-based management GUI in the switch
- **Security banner**: displays a customized security policy when users log in to the switch

Multicast support

- **IP multicast routing (requires Premium License)**: includes PIM Sparse and Dense modes to route IP multicast traffic
- **IP multicast snooping (data-driven IGMP)**: automatically prevents flooding of IP multicast traffic

Quality of Service (QoS)

- **Layer 4 prioritization**: enables prioritization based on TCP/UDP port numbers
- **Class of Service (CoS)**: sets the IEEE 802.1p priority tag based on IP address, IP Type of Service (ToS), L3 protocol, TCP/UDP port number, source port, and DiffServ
- **Bandwidth shaping**:
  - **Port-based rate limiting**: per-port ingress/egress enforced maximum bandwidth
  - **Classifier-based rate limiting**: use ACL to enforce maximum bandwidth for ingress traffic on each port
  - **Guaranteed minimum**: per-port, per-queue egress-based guaranteed minimum bandwidth
- **Advanced classifier-based QoS**: classifies traffic using multiple match criteria based on L2/L3/L4 information; applies QoS policies such as setting priority level and rate limit to selected traffic per port or per VLAN
- **Traffic prioritization**: allows real-time traffic classification into eight priority levels mapped to eight queues

Warranty and support

- **ProCurve Lifetime Warranty**: for as long as you own the product, with next-business-day advance replacement (available in most countries)
- **Electronic and telephone support**: limited electronic and telephone support is available from HP; refer to the HP website at **www.procurve.com/support** for details on the support provided and the period during which support is available
- **Software releases**: refer to the HP website at **www.procurve.com/support** for details on the software releases provided and the period during which software releases are available

Standards and protocols

Refer to HP ProCurve 6600 Switch Series datasheet for latest standards support available at **www.procurve.com/products/pdfs/datasheets/HP_ProCurve_6600_Switch_Series.pdf**.

Capacity, performance, and features

6600 series comparison

Table 6 provides a comparison of several categories of capacity and performance levels for the ProCurve 6600 Switch Series. These include the routing and switching capacity (Gbps), switch fabric speed (Gbps), maximum number of 1 Gbps that can operate concurrently at wire speed, the maximum number of 10-Gbps ports that can operate concurrently at wire speed, and the size of the routing table (entries).

	6600-24G	6600-24G-4XG	6600-48G	6600-48G-4XG	6600-24XG
Rack height	1U	1U	1U	1U	1U
1-Gb RJ-45	24	24	48	48	–
1-Gb SFP	4*	4*	4*	–	–
10-Gb SFP+	–	4	–	4	24
Max. 1-Gb wire-speed ports	24	24	48	48	–
Max. 10-Gb wire-speed ports	–	2	–	4	12
Out-of-band mgmt. port	–	–	Yes	Yes	Yes
Power save option	–	–	Yes	Yes	Yes
Routing/Switching capacity	48.0 Gbps	101.8 Gbps	96.0 Gbps	176.0 Gbps	322.8 Gbps
Switch throughput	35.7 mpps	75.7 mpps	71.4 mpps	130.9 mpps	240.2 mpps
MAC address entries	64K	64K	64K	64K	64K
ACL entries	3K	3K	3K	3K	3K
Routing table entries	10K	10K	10K	10K	10K
Power supplies	2 internal power supply slots (includes 1 hot-swappable power supply)				
Airflow	Front-to-back airflow with redundant, hot-swappable fan tray				
Power consumption** (idle/max.)	109 W/162 W	149 W/196 W	180 W/209 W	226 W/261 W	277 W/314 W
Idle port power save	–	–	Yes	Yes	Yes
Product depth	20 in. (51 cm)	20 in. (51 cm)	24 in. (61 cm)	24 in. (61 cm)	24 in. (61 cm)

*Dual-personality ports

Table 6: Capacity, performance, and features comparison of the 6600 series products

Routing and forwarding tables

The ProCurve 6600 Switch Series has several routing and forwarding table features that enhance routing and switching performance. Every NG/NGX interface has its own "best-match prefix" routing table that contains IP routes and is used for determining how to route the vast majority of incoming packets. Using the best-match prefix routing table is extremely fast and enables wire-speed routing to be achieved. If the best-match prefix routing table does not contain an entry that can be used to determine the route of a received packet, then the main routing table is used. The main routing table can contain up to 10,000 routing table entries.

For Layer 2 forwarding, each switch has a forwarding or MAC table that can contain up to 65,536 entries (64K).

Optimizing the 10-GbE port configuration for wire speed

For the 6600-24XG and the 6600-24G-4XG switch, where the 10-GbE interfaces are oversubscribed 40G:28.8G, these switches are designed to deliver full 10-Gbps wire speed to either one or two ports that are in a linked state with another device. When three or four ports per block of four 10-GbE ports are in a linked state, the group of 4 x 10-GbE ports support an aggregate bandwidth of 28.8 Gbps across the linked ports.

Note: The 6600-48G-4XG switch supports full line rate 10-Gb performance, so this section does not apply to that particular switch.

As illustrated in Figure 18, internally, there are two 14.4-Gbps channels between each four-port 10-GbE block and the switch fabric.
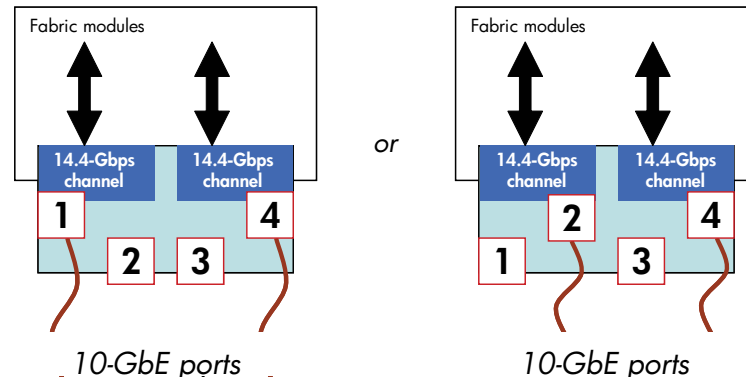

Figure 18: 4-port 10-GbE blocks showing how ports are grouped to a 14.4-Gbps channel

When any two 10-GbE ports within a 4-port block are in a linked state, each port automatically operates on its own channel, which provides 10-GbE of bandwidth for each port. The two ports are dynamically mapped to an available high-speed channel and support full 10-GbE wire-speed operation.
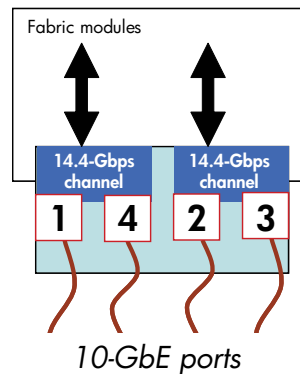
Figure 19: 10-GbE module architecture showing four 4 ports grouped to 14.4-Gbps channel

However, when more than two ports per four 10-GbE block are in a linked state, ports 1 and 4 are statically mapped to share one 14.4-Gbps channel, while ports 2 and 3 are statically mapped to share the other 14.4-Gbps channel. Thus, if only one port in a given channel is in a linked state, then that port operates at wire speed and the other port uses no bandwidth. However, if both ports in a given channel are in a linked state, then the 14.4 Gbps of bandwidth is balanced fairly between the two ports.

For example, in an application where three 10-GbE ports are needed and the user needs to ensure that port 1 always has a full 10 Gbps available, then port assignments shown in Figure 20 should be used to ensure that port 1 can operate at wire speed.
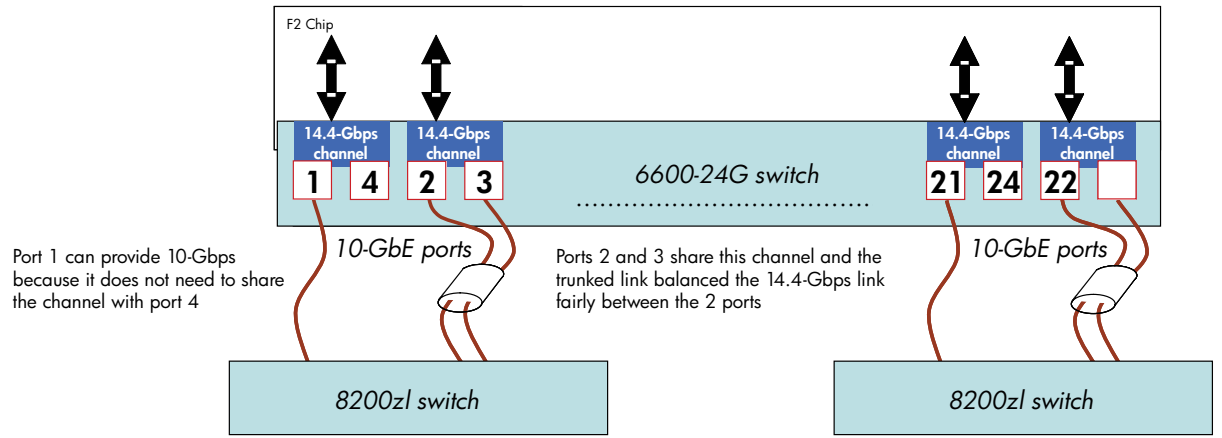
Figure 20: Approach for providing 10 Gbps on a specific port

Connection choices are also important where equally balanced bandwidth is needed, such as in a VRRP application. This scenario is illustrated in Figure 21.

- Each trunk provides 20-Gbps bandwidth because in the VRRP scenario, one router is the owner and the other is the backup
- As a result, only one port in each 14.4-Gbps channel is in use because the trunks are using different channels
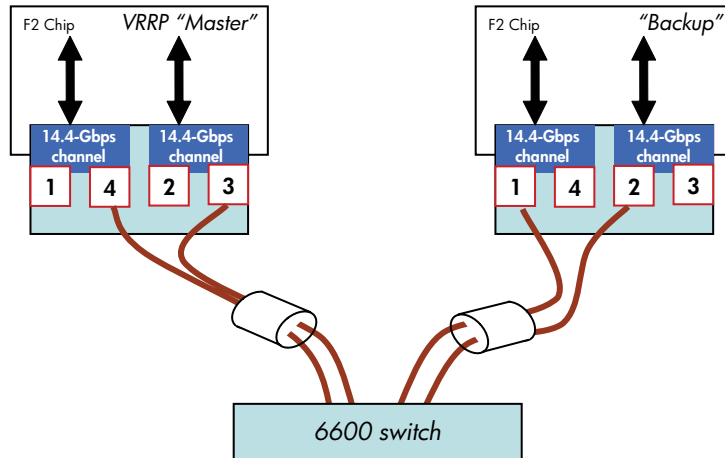
Figure 21: Providing equally balanced bandwidth in a VRRP environment

Throughput and latency performance data

Tables 7 through 9 describe the performance capabilities of the 10-Gbps, 1-Gbps, and 100-Mbps interface module ports of the ProCurve 6600 Switch Series. Over a range of packet sizes from 64 bytes to 1518 bytes, the performance levels achieved are described in terms of the following metrics:

- Throughput level percentage achieved when performing Layer 2 switching and Layer 3 routing; 100% in all cases.
- Throughput in the form of the number of packets per second when performing Layer 2 switching and Layer 3 routing.

- Average per-packet latency in microseconds when performing Layer 2 switching and Layer 3 routing. These values shown are listed for both First-In-First-Out (FIFO) and Last-In-First-Out (LIFO) processing. The LIFO values represent the packet transmit time, whereas the FIFO values include the switch decision time and the packet transmit time.
- Percentage of packets dropped in a full mesh configuration; 0% in all cases.

The following measurements were performed by ProCurve using test equipment manufactured by Ixia Communications (www.ixiacom.com). In these tests, the maximum number of supported ports on the ProCurve 6600 switch was used. Proportional performance results at 100% of throughput are achieved on the ProCurve 6600 Switch Series for the maximum number of ports supported by each models. The 1-Gbps table is not applicable to the 6600-24XG switch because only 10-Gb ports are supported.

10 Gbps	Throughput %	Packets per second	Full mesh	Latency (FIFO)		Latency (LIFO)	
Packet size	L2/L3	L2/L3	% drops	L2 (ms)	L3 (ms)	L2 (ms)	L3 (ms)
64[1]	100	14880952	0	2.36	3.46	2.30	3.40
128	100	8445946	0	2.53	3.58	2.40	3.45
256	100	4528986	0	2.875	3.8	2.68	3.61
512	100	2349624	0	3.49	4.24	3.10	3.85
1024	100	1197318	0	4.80	5.14	3.98	4.32
1280	100	961538	0	5.47	5.6	4.42	4.55
1518	100	811688	0	6.00	6.00	4.00	4.78

1 Gbps	Throughput %	Packets per second	Full mesh	Latency (FIFO)		Latency (LIFO)	
Packet size	L2/L3	L2/L3	% drops	L2 (ms)	L3 (ms)	L2/L3	L2/L3
64	100	1488095	0	3.38	3.38	2.84	2.84
128	100	844595	0	4.02	4.02	2.99	2.99
256	100	452899	0	5.14	5.14	3.09	3.09
512	100	234962	0	7.42	7.42	3.32	3.32
1024	100	119732	0	12.06	12.06	3.86	3.86
1280	100	96154	0	14.3	14.3	4.04	4.04
1518	100	81274	0	16.42	16.42	4.27	4.27

[1] See the explanation about 10-Gb performance traffic patterns in the next section.

Table 7: 6600 series throughput performance

10-Gb performance traffic patterns

In Table 7, the performance levels for 10-Gb ports assume the underlying traffic patterns reflect either one of the following minimum conditions to achieve wire-speed throughput:

- *A single source* traffic stream with an average packet size of *88 bytes or larger*
- *Two or more source* traffic streams of *any packet size* down to the minimum value of 64 bytes

In the unlikely case where the average packet size is consistently smaller, the throughput will be less than wire speed. For example, consider a worst-case scenario, where the average packet size is 64 bytes. This would result in a throughput of approximately 70% to 80% of the rated wire-speed capacity. ProCurve considers such minimum-sized, packet traffic scenarios being realized over an extended period of time to be extremely atypical and unlikely to be experienced by customers in the field.

Note: The limits described here do not apply to Gigabit ports.

Throughput test

A fully meshed performance test sends packets from each port to every other port during the test. This type of test exercises both the modules and the backplane. These tests show the ProCurve 6600 Switch Series to achieve wire speed on all ports simultaneously.

Latency measurements

Latency is commonly measured as the amount of time it takes for a byte inside a packet to enter and then leave the switch. Latency statistics typically are documented as including both the processing time of the switch as it makes its forwarding decision, and the time for the packet itself to enter and leave the switch. In Table 7, this definition of latency corresponds to the FIFO latency statistics. The LIFO latency statistics that also are listed in the table represent only the packet transmission time.

Almost all switches currently on the market are store and forward, so the entire packet is received into the switch before the switch begins to transmit the packet out the egress port. Including the packet receive time in the FIFO latency statistics is appropriate, because this extra time is a contributing component of the overall transit time of the packet as it moves through the network.

The latency figures for the ProCurve 6600 Switch Series are consistently low. Latencies this low will not be a factor in general network operation, even with streaming video or VoIP applications. The LIFO latency values are fairly consistent across all packet sizes due to the fact that ingress and egress packet processors operate on the header of the frame (not the whole frame), while the full frame is buffered in and out of packet buffer memory. Memory transfers are scheduled to fit a full 1518-byte frame, so frames are transferred in and out of memory in approximately the same amount of time, regardless of packet size. While the frame headers are being looked up, and actions required for the frame on egress are being coordinated among interface modules, the frame is transferred through the switching fabric module.

Power consumption measurements

Table 8 details the expected power consumption on the various 6600 series switches with one and two power supply configurations.

	6600-24G	6600-24G-4XG	6600-48G	6600-48G-4XG	6600-24XG
1 PSU configuration					
Idle power	93 W	127 W	144 W	191 W	310 W
Max. power	125 W	172 W	175 W	227 W	372 W
Max. heat dissipation	425 Btu/hr	587 Btu/hr	597 Btu/hr	774 Btu/hr	1267 Btu/hr
2 PSU configuration					
Idle power	129 W	168 W	180 W	226 W	345 W
Max. power	160 W	204 W	209 W	261 W	405 W
Max. heat dissipation	545 Btu/hr	697 Btu/hr	713 Btu/hr	890 Btu/hr	1382 Btu/hr

Note: Maximum power includes all ports connected and forwarding data at 100% utilization. Idle power was measured with all ports connected but not forwarding data.

Table 8: 6600 series power consumption measurements

Power Save mode

Certain models of the 6600 series switches have implemented advanced power-saving capabilities to reduce power consumed by unused or idle ports. The 6600-24XG, 6600-48G, and 6600-48G-4XG switches allow users to turn off groups of ports to save power by entering the CLI *savepower* command at the global configuration level.

Ports are grouped into power domains on each 6600 switch. To enable Power Save mode, you must enter a *power domain* number with the *savepower* command. The amount of power saved by powering down a port group is shown in Table 9.

6600-24XG Power Save mode

Power domain	Port range	Power savings
1	01–08	70 W
2	09–16	70 W
3	17–24	70 W

6600-48G-4XG Power Save mode

Power domain	Port range	Power savings
1	01–24	35 W
2	25–48	35 W
3	49–52 (SFP+)	50 W

6600-48G Power Save mode

Power domain	Port range	Power savings
1	01–24	35 W
2	25–48	35 W

Note: The Power Save mode configured with the *savepower* command is only a temporary setting, and is not retained after a power cycle or reboot.

Table 9: Expected energy savings from 6600 Power Save mode

Services and support

Lifetime warranty

Warranties, and the ease of obtaining warranty service for the customer, is a product benefit that is easily overlooked in a technical evaluation, but ranks high as a concern of customers as they get ready to actually make a purchase decision. The ProCurve 6600 Switch Series has a lifetime warranty for as long as you own the product. If any part of the switch fails due to a defect in material or workmanship, including the power supply or fans, it will be replaced. In most parts of the world, the replacement unit is sent with next-business-day delivery in advance of the failing unit being returned to HP.

Advance replacement gets the unit to the customers as quickly as possible and reduces downtime by allowing the impaired unit to continue to be used if possible until the replacement unit arrives. This also allows for easy scheduling for when the actual unit swap occurs on the network. An optional upgrade to onsite replacement is also available in most parts of the world. For more details about warranty coverage, refer to the warranty statement that is shipped with the product.

The ProCurve 6600 Switch Series and 8200zl, 6200yl, 5400zl, and 3500yl series warranties are industry leading.

Free telephone support

ProCurve provides free pre-sales and post-sales telephone support during normal business hours to end users and ProCurve resellers through the ProCurve Customer Care Centers located worldwide.

Optional support services

In addition to free support services such as the warranty and telephone support, ProCurve offers an extensive range of fee-based support services to meet more specialized needs. The following optional services are available for the ProCurve 6600 Switch Series:

- Onsite next business day
- Onsite in four hours, same business day
- Onsite in four hours 24 x 7
- Six-hour call-to-repair
- 24 x 7 telephone support

HP also can provide more broad-based services such as site surveys, installation services, and actual management of the network, depending on customer needs.

More information can be found at **www.hp.com/rnd/services/index.htm** or by contacting a local ProCurve sales office.

Appendix A: out-of-band management port

The out-of-band management (OOBM) interface provides an 10/100 Ethernet-based isolated management interface to access the switch via SNMP, HTTP, SSH, and Telnet. As a truly isolated port, it is not connected to the switching fabric and runs an IP stack that is separate from the in-band data plane. In a typical deployment, the OOBM port should be connected to an isolated management network, both physically and logically, to provide better security and allow for remote, lights-out management of the network. Figure A-1 highlights the typical use model for an Ethernet out-of-band management network.
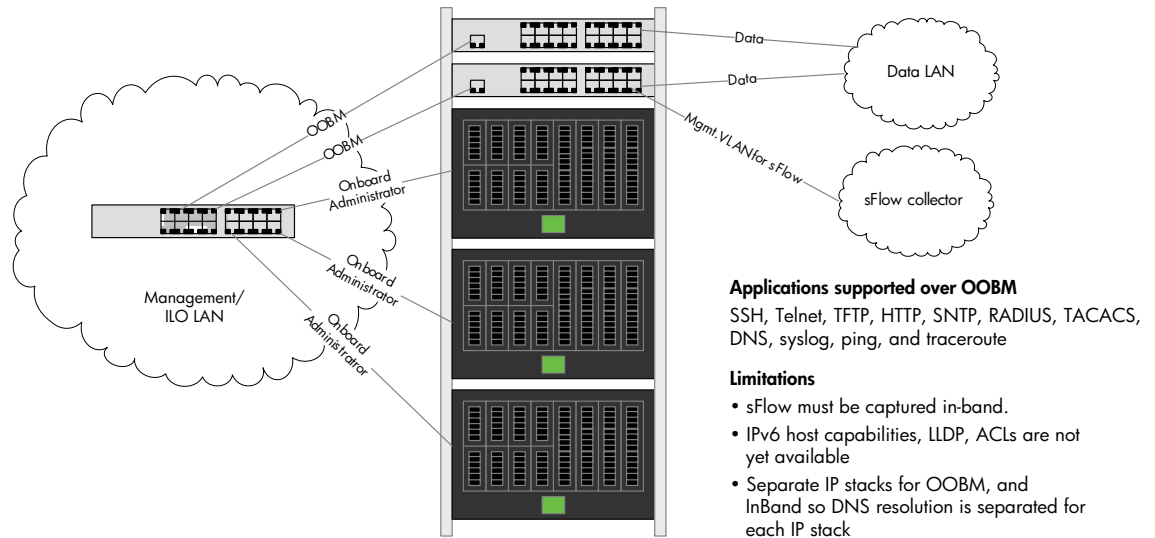

Applications supported over OOBM
SSH, Telnet, TFTP, HTTP, SNTP, RADIUS, TACACS, DNS, syslog, ping, and traceroute

Limitations
- sFlow must be captured in-band.
- IPv6 host capabilities, LLDP, ACLs are not yet available
- Separate IP stacks for OOBM, and InBand so DNS resolution is separated for each IP stack

Figure A-1: Out-of-band management use model

OOBM availability

The OOBM port is available on 6600-48G, 6600-48G-4XG, and 6600-24XG products and is enabled using K.14.32 code or later.

Applications supported with OOBM port

The following applications are supported with the OOBM port: SSH, Telnet, TFTP, HTTP, SNTP, RADIUS, TACACS, DNS, syslog, ping, and traceroute.

OOBM limitations

- **sFlow**: It is not possible to send sFlow samples to a collector over the OOBM port sFlow must be captured and sent in-band.

- **OOBM futures**: Features to be implemented in the future, though no time frame has been committed, include IPv6 host capabilities, LLDP discovery, and ACLs.

- **DNS resolution**: Because the OOBM supports a separate IP stack, DNS resolution is separated from the in-band plane.

Appendix B: Policy Enforcement Engine

The ProVision ASIC architecture used in the ProCurve 6600 Switch Series, 8200zl, 5400zl, 3500yl, and 6200yl Series brings a number of advanced capabilities to the network that offer a highly reliable, robust environment that leads to increased network uptime, keeping overall network costs down. One major feature is the ProVision Policy Enforcement Engine, which is implemented in the ProVision ASIC of each interface module.

Policy Enforcement Engine benefits

The Policy Enforcement Engine has several benefits.

Granular policy enforcement

The initial software release on these products takes advantage of a subset of the full Policy Enforcement Engine capabilities, which will provide a common front end for the user interface to ACLs, QoS, Rate-Limiting, and Guaranteed Minimum Bandwidth controls. Fully implemented in later software releases, the Policy Enforcement Engine provides a powerful, flexible method for controlling the network environment. For example, traffic from a specific application (TCP/UDP port) can be raised in priority (QoS) for some users (IP address), blocked (ACL) for some other users, and limited in bandwidth (Rate-Limiting) for still other users.

The Policy Enforcement Engine provides fast packet classification to be applied to ACLs and QoS rules and Rate-Limiting and Guaranteed Minimum Bandwidth counters. Parameters that can be used include source and destination IP addresses, which can follow specific users, and TCP/UDP port numbers and ranges, which are useful for applications that use fixed-port numbers. More than 14 different variables can be used to specify the packets to which ACL, QoS, Rate-Limiting, and Guaranteed Minimum Bandwidth controls are to be applied.

Hardware-based performance

As mentioned earlier, the Policy Enforcement Engine is a part of the ProVision ASIC. The packet selection is done by hardware at wire speed except in some very involved rules situations. Therefore, very sophisticated control can be implemented without adversely affecting performance of the network.

Works with HP ProCurve Data Center Connection Manager ONE

HP Data Center Connection Manager ONE provides the centralized automation based on predetermined server connection profiles that define network requirements for each physical and virtual server. The Data Center Connection Manager ONE subscription request is sent down to the individual switch port and is used to set up a server profile in the Policy Enforcement Engine so that the per-VM ACL, QoS, and Rate-Limiting parameters can be used from the actual policy defined in Data Center Connection Manager ONE.

Wire-speed performance for ACLs

At the heart of the Policy Enforcement Engine is a memory area called the Ternary Content Addressable Memory (TCAM) that is contained within the ProVision ASIC, along with the surrounding code for the Policy Enforcement Engine.

It is this specialized memory area that helps the ProVision ASIC to achieve wire-speed performance when processing ACLs for packets. In fact, multiple passes through the TCAM can be performed for packet sizes that are found typically in customers' production networks. For the typical network, the average packet size will tend to be about 500 bytes. When maximum lookups are enabled, the ProVision ASIC performance is optimal for an average packet length of 200 bytes or more, which includes the range of packet sizes in typical networks.

The TCAM can support approximately 3,000 data entries that may be used to represent various traffic controls, including ACLs. For most customers, this quantity of entries will be more than adequate to provide wire-speed performance for ACL processing. Keep in mind that each ACL entry may consist of multiple criteria, such as a specific IP address and TCP or UDP port number.

Appendix C: PIM-Sparse Mode

In Protocol Independent Multicast-Sparse Mode (PIM-SM), the assumption is that no hosts want the multicast traffic unless they ask for it specifically. In contrast, PIM-Dense Mode (PIM-DM) assumes downstream router membership unless it receives an explicit prune message. PIM-SM is appropriate for wide-scale deployment for both densely and sparsely populated groups, and is the best choice for all production networks, regardless of size and membership density.

The operation of PIM-SM centers on the use of a shared tree, with a router functioning as a rendezvous point (RP), as the root of the tree. A shared tree prevents each router from maintaining source and group state information for every multicast source. Regardless of the number or location of multicast receivers, multicast senders register with the RP and send a single copy of multicast data through it to the registered receivers. Also, regardless of the location or number of sources, group members register to receive data and always receive it through the RP.
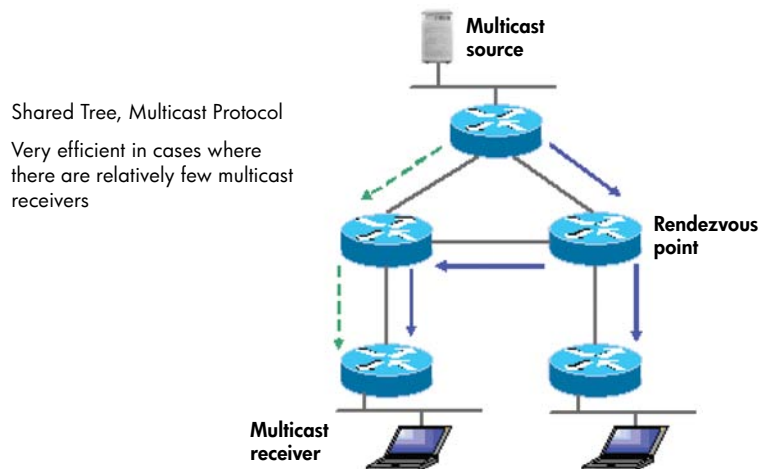

Figure C-1: PIM: Shared Tree example topology

In order to receive a multicast stream, routers explicitly join the stream by sending "join" messages to the RP. This join message is analogous to a unicast router following a default route to a destination. Effectively, the function of the RP is a place for multicast sources and receivers to meet.

PIM-SM is extremely memory and CPU efficient. Because the only thing most routers need to know is how to reach the RP, memory requirements are reduced greatly. There are several methods that can be used by routers in a PIM-SM domain to learn where to find the RP. Probably the simplest mechanism is statically configuring all routers to reach the RP. However, if the routers are configured statically to an RP and the RP fails, then the multicast network is no longer functional.

Alternatively, the RP can be learned dynamically through the PIM-SM bootstrap mechanism. Because this bootstrap mechanism is dynamic, it allows for network changes and redundancy. The PIM-SM bootstrap mechanism is generally the recommended approach for simplicity and redundancy.

Appendix D: virus throttle security

Virus throttle is based on the detection of anomalous behavior of network traffic that differs from a normal activity. Under normal activity, a server will make fairly few outgoing connections to new clients or servers, but instead, is more likely to connect regularly to the same set of end nodes. This is in contrast to the fundamental behavior of a rapidly spreading worm, which will attempt many outgoing connections to new computers. For example, while computers normally make approximately one connection per second, the SQL Slammer virus tries to infect more than 800 systems per second.

Virus throttle works by intercepting IP-routed connection requests—connections crossing VLAN boundaries—in which the source subnet and destination subnet are different. The virus throttle tracks the number of recently made connections. If a new, intercepted request is to a destination to which a connection was recently made, the request is processed as normal. If the request is to a destination that has not had a recent connection, the request is processed only if the number of recent connections is below a pre-set threshold. The threshold specifies how many connections are to be allowed over a set amount of time, thereby enforcing a connection-rate limit. If the threshold is exceeded, because requests are coming in at an unusually high rate, it is taken as evidence of a virus. This causes the throttle to stop processing requests and to instead notify the system administrator.

This applies to most common Layer 4 through 7 session and application protocols, including TCP connections, UDP packets, SMTP, IMAP, Web Proxy, HTTP, SSL, and DNS—virtually any protocol where the normal traffic does not look like a virus spreading. For virus throttle to work, IP routing and multiple VLANs with member ports must first be configured.

Note that some protocols, such as NetBIOS and WINS, and some applications such as network management scanners, notification services, and P2P file sharing, are not appropriate for virus throttle. These protocols and applications initiate a broad burst of network traffic that could be misinterpreted by the virus-throttle technology as a threat.
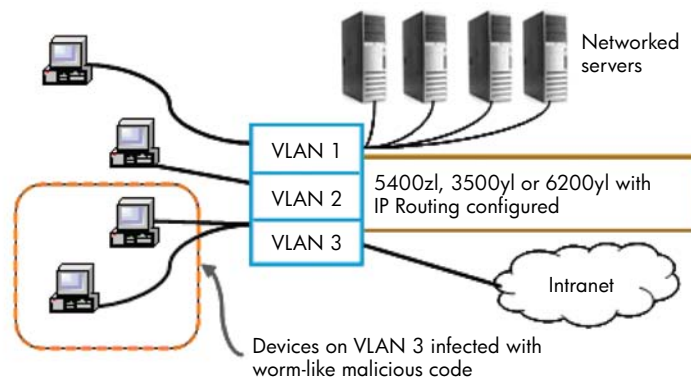

Figure D-1: Virus Throttle example topology

On the ProCurve 6600 Switch Series virus throttle is implemented through connection-rate filtering. When connection-rate filtering is enabled on a port, the inbound routed traffic is monitored for a high rate of connection requests from any given host on the port. If a host appears to exhibit the worm-like behavior of attempting to establish a large number of outbound IP connections in a short period of time, the switch responds, depending on how connection-rate filtering is configured.

Response options

The response behavior of connection-rate filtering can be adjusted by using filtering options. When a worm-like behavior is detected, the connection-rate filter can respond to the threats on the port in the following ways:

- **Notify only of potential attack**: While the apparent attack continues, the switch generates an Event Log notice identifying the offending host source address (SA) and (if a trap receiver is configured on the switch) a similar SNMP trap notice.

- **Notify and reduce spreading**: In this case, the switch temporarily blocks inbound routed traffic from the offending host source address for a "penalty" period, and generates an Event Log notice of this action and a similar SNMP trap notice if a trap receiver is configured on the switch. When the penalty period expires, the switch reevaluates the routed traffic from the host and continues to block this traffic if the apparent attack continues. During the reevaluation period, routed traffic from the host is allowed.

- **Block spreading**: This option blocks routing of the host's traffic on the switch. When a block occurs, the switch generates an Event Log notice and a similar SNMP trap notice if a trap receiver is configured on the switch. Note that system personnel must explicitly re-enable a host that has been previously blocked.

Sensitivity

The ability of connection-rate filtering to detect relatively high instances of connection-rate attempts from a given source can be adjusted by changing the global sensitivity settings. The sensitivity can be set to low, medium, high, or aggressive, as described below.

- **Low**: Sets the connection-rate sensitivity to the lowest possible sensitivity, which allows a mean of 54 routed destinations in less than 0.1 seconds, and a corresponding penalty time for Throttle mode (if configured) of less than 30 seconds.
- **Medium**: Sets the connection-rate sensitivity to allow a mean of 37 routed destinations in less than one second, and a corresponding penalty time for Throttle mode (if configured) between 30 and 60 seconds.
- **High**: Sets the connection-rate sensitivity to allow a mean of 22 routed destinations in less than one second, and a corresponding penalty time for Throttle mode (if configured) between 60 and 90 seconds.
- **Aggressive**: Sets the connection-rate sensitivity to the highest possible level, which allows a mean of 15 routed destinations in less than one second, and a corresponding penalty time for Throttle mode (if configured) between 90 and 120 seconds.

Connection-rate ACL

Connection-rate ACLs are used to exclude legitimate high-rate inbound traffic from the connection-rate filtering policy. A connection-rate ACL, consisting of a series of access control entries, creates exceptions to these per-port policies by creating special rules for individual hosts, groups of hosts, or entire subnets. Thus, the system administrator can adjust a connection-rate filtering policy to create and apply an exception to configured filters on the ports in a VLAN.

Appendix E: VRRP

Virtual Router Redundancy Protocol (VRRP) is designed to eliminate the single point of failure inherent in the static default routed environment. In a VRRP environment, two or more "virtual" routers cooperate to provide a high-availability capability on a LAN. VRRP specifies an election protocol that dynamically assigns routing responsibility to one of the virtual routers on a LAN.

A virtual router consists of a set of router interfaces on the same network that shares a virtual router identifier (VRID) and a virtual IP address. One router in the group becomes the VRRP Master and the other routers are designated as VRRP Backups. The VRRP Master controls the IP addresses associated with a virtual router.

The VRRP Master router periodically sends advertisements to a reserved multicast group address. The VRRP Backup routers listen for advertisements and one of the backups will assume the Master role, if necessary. A VRRP router can support many virtual router instances, each with a unique VRID/IP address combination. The election process provides dynamic failover to one of the remaining VRRP Backups should the Master become unavailable.

VRRP is an election protocol that dynamically assigns responsibility for a virtual router on a LAN

Provides High Availability for a default gateway without the need to reconfigure end hosts
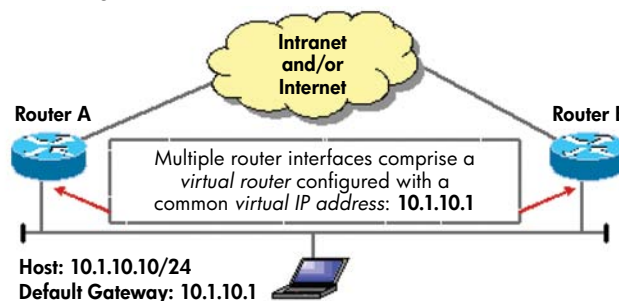
Intranet and/or Internet

Router A

Router B

Multiple router interfaces comprise a *virtual router* configured with a common *virtual IP address*: **10.1.10.1**

Host: 10.1.10.10/24
Default Gateway: 10.1.10.1

Figure E-1: VRRP example topology

The virtual IP address shared by a group of VRRP routers on a given network segment functions as the next-hop IP address used by neighboring hosts. The VRRP Master router simply forwards packets that have been received from hosts using the VRRP Master as the next-hop gateway. The existence of a VRRP master and of one or more VRRP Backups is transparent to the neighboring hosts. The advantage gained from using VRRP is that it is a default path with higher availability, but it does not require configuration of dynamic routing or router discovery protocols on every end host. VRRP on ProCurve switches is interoperable with other routers that support RFC 3768. VRRP operational aspects include the following:

• Preemptive mode, which can be disabled to prevent VRRP router flapping

• Default Advertisement interval of one second

• Default Detection time of 3.6 seconds

Appendix F: OSPF Equal Cost Multipath

In Open Shortest Path First (OSPF), if different subnet destinations in a network are reachable through multiple equal-cost, next-hop routes, the router chooses the same next-hop route at a given point in time to send traffic to destinations reachable through that next-hop router. With OSPF Equal Cost Multipath (OSPF-ECMP), routers support optional load-sharing across redundant links where the network offers two or more equal-cost next-hop routes for traffic to different subnets. All traffic for different hosts in the same subnet goes through the same next-hop router. Multiple paths are balanced based on the number of destination subnets. ProCurve's OSPF-ECMP feature is interoperable with OSPF-ECMP implementations from various vendors, including Cisco, 3Com, and Extreme Networks. The ProCurve implementation supports up to four ECMP links, and traffic is load-balanced on a round-robin basis per source/destination IP address pair. Thus, traffic sharing the same source/destination IP address will always choose the same path.
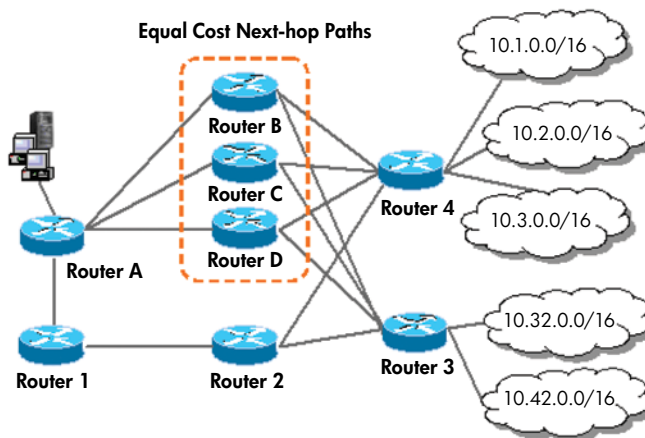

Figure F-1: OSPF ECMP example topology

Figure F-1 shows that there are three equal-cost, next-hop paths from Router A to the destination subnets with load-sharing across redundant links. At any point in time, Router A's routing table could have information indicating the following:

Destination subnet	Next hop
10.1.0.0/16	Router C
10.2.0.0/16	Router D
10.3.0.0/16	Router B
10.32.0.0/16	Router B
10.42.0.0/16	Router D

Appendix G: troubleshooting

LED status indicators for 6600 series

The ProCurve 6600 Switch Series management module has various LED status indicators that are described in Table G-1.

LED	State	Indication
Power	On (green)	The switch is receiving power.
	Off	The switch is NOT receiving power.
Fault	On (orange)	On briefly at the beginning of switch self-test, after the switch is powered on or reset. If on for a prolonged time, the switch has encountered a fatal hardware failure, or has failed its self-test.
	Off	The normal state; indicates there are no fault conditions on the switch.
	Blinking (orange)	A fault has occurred on the switch, one of the switch modules, an individual port, a power supply, or a fan. The Status LED for the module or other device with the fault will flash simultaneously.
Test	On (green)	The switch self-test and initialization are in progress after you have power-cycled or reset the switch. The switch is not operational until this LED goes off. The Self-Test LED also comes on briefly when you "hot-swap" a module into the switch and the module is automatically self-tested.
	Off	Normal operation; the switch is not undergoing self-test.
	Blinking (orange)	A component of the switch has failed its self-test. The Status LED for that component, for example, a switch module, and the switch Fault LED will flash simultaneously.
Temperature	On	Internal temperature is normal.
	Blinking (orange)	An over-temperature condition has been detected.
Fan	On (green)	Normal operation.
	Blinking (orange)	One or more of the switch's fans have failed. The switch Fault LED will be blinking simultaneously.
PS	On (green)	A power supply is installed in the position in the back of the switch, and the supply is plugged into an active AC power source. As shipped, the switch has a single power supply in position 1.
	Blinking (orange)	One of the switch's redundant power supplies has failed. The switch Fault LED will be blinking simultaneously.
	Blinking (orange)	The external power supply has a fault or, is connected but not plugged into AC power.

LED	State	Indication
LED Mode Select	Act (green)	Flickers to show relative activity.
	FDx (green)	Flickers to show relative activity.
	PoE (green)	Indicates which ports are supplying power. • If the Mode LED is on, the port is providing PoE power. • If the Mode LED is off, the port is not providing PoE power. • If the Link LED is on, the port is enabled for PoE. • If the Link LED is off, the port is disabled for PoE. • If the Link LED is blinking, the port has an error or the port is denied power due to insufficient power.
	Spd (green)	Indicates speed of operation of each port. • If the Port LED is off, the port is operating at 10 Mbps. • If the Port LED is blinking, the port is operating at 100 Mbps. • If the Port LED is on continuously, the port is operating at 1000 Mbps.
	Usr (green)	Reserved for future development.

Table G-1: LED status indicators for management/system support module

The LED status indicators for the ProCurve 6600 switch ports are described in Table G-2.

LED	State	Indication
Link	On (green)	Indicates the port is enabled and receiving a link beat signal (for the twisted-pair ports), or a strong enough light level (for the fiber-optic ports) from the connected device.
	Off	Indicates no active network cable is connected to the port, the port is not receiving link beat or sufficient light, or the port has been disabled.
	Blinking (orange)	If the port LED is blinking simultaneously with the Fault LED, the corresponding port has failed its self-test.
Mode		Depending on the mode selected, displays: • Network activity information • Whether the port is configured for full duplex operation • Maximum speed operation

Table G-2: LED status indicators for ProCurve 6600 Switch Series Ethernet ports

Appendix H: links to other useful documents

White papers

Resources for Cisco interoperability, Data Center Connection Manager, Green, and so on, can be found at
www.procurve.com/library/whitepapers.aspx

Technical briefs

Storage over Ethernet sources can be found at
www.procurve.com/docs/datacenter/Storage_Over_Ethernet_Technical_Brief_Dec_08_WW_Eng_Ltr.pdf

Documents related to 6600 series and the data center

Sources about the 6600 series and the data center can be found at
www.procurve.com/library/view_by_product.aspx#Switch%206600

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ProCurve Networking